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EDUCATIONAL POLICY AND MAN-POWER

THE debate on scientific and technical man-power in Great Britain which was initiated by Mr. Austen Albu in the House of Commons on July 21 added little to the observations on that subject which have since been published in the report of the Advisory Council for Scientific Policy. The debate was noteworthy, however, for the way in which it related the man-power situation in Britain to educational policy as a whole, and it also elicited from the Minister of Education a statement as to educational policy, and particularly the policy he envisages for technical education. Much that Sir David Eccles said was fundamentally sound, and the full statement which he promised to make before Christmas will be awaited with great interest. The very fact, however, that Sir David Eccles confined himself, on this issue of scientific and technical man-power, to the expansion of technological and technical education, and left the question of university education to be dealt with by the Financial Secretary to the Treasury, emphasizes the unhappy division which has been responsible for so much frustration and futility in the past.

Neither Sir David's speech nor that of Mr. Henry Brooke gave any indication that this position is to be remedied, and Sir David's rather lame attempt in defence of his recent acceptance of the recommendation in the report of the National Advisory Council for Education for Industry and Commerce for the institution of a new award for technology damps hopes of a new and vigorous policy which his speech might otherwise have raised. There is little indication that the real issues are appreciated, and resources and effort will apparently continue to be distributed too widely or frittered away on non-essentials instead of being concentrated where they will be most effective. Sir David rightly emphasized that we should not expect to expand the output of scientists and technologists or technicians cheaply; but he has equally pointed out the necessity of careful selection and timing in order that our limited resources may be expended to the best advantage. That cannot be done without a clearer conception of the relation between technological and technical and university education than was shown by the Government speakers in this debate. The Minister fully recognized the human aspect of the problem and that it is not a matter merely of providing facilities: it is also a matter of persuading more boys and girls to continue their education in particular ways and to adopt particular careers. The creation of a favourable public opinion is a most important factor in securing the conditions which will induce boys and girls to adopt the careers which the public interest at any particular time demands, whether it be as science teachers in the schools, as teachers of technology in the colleges of technology or the universities, or as technicians and technologists in industry or the public corporations or State departments themselves.

This is a matter which calls for close co-operation, not merely between industry and the colleges of technology and technical colleges, but also with the secondary schools and the universities and university colleges. The bias against a career in industry or technology is only likely to be removed when the value of technology as an intellectual discipline itself is fully recognized within as well as without the universities. This is an essential factor in inducing a sufficient number of the ablest students to adopt a career in applied science and in attracting to the colleges of technology teachers of outstanding ability. The real objection to the proposed new award is that it does nothing to help the colleges of technology or the technical colleges to gain the status that alone will give the award any value. It ignores the extent to which the professional institutions already provide hallmarks of proficiency, and may well divert effort which could be better expended in creating the teaching conditions and facilities likely to attract teachers of the necessary calibre.

It was clear from Sir David's remarks here that he did not appreciate the importance of academic autonomy as a condition of obtaining staff of the highest qualifications and ability for selected colleges of technology, nor that the number of such men and women is too limited to hold out any real hope of staffing twenty, let alone thirty, colleges of technology on the scale necessary. Sir Hugh Linstead, indeed, questioned the practicability of so staffing more than half a dozen colleges. While, too, there can be no doubt as to the importance of securing the full interest and support of the local authorities, the Minister's view that the colleges of technology selected for development as regional centres cannot therefore be independent of local control is open to challenge. The surrender by the Manchester City Council of its share with the University in the administration of the Manchester College of Technology on the grant of the Royal Charter to the College shows that local authorities may well possess more vision and judgment than the Minister allows. This new charter provides for the setting up of an independent board of governors appointed by interested bodies and, seeing that the Royal Charter has been granted at the request of the Manchester City Council, the University of Manchester and the County Councils of Lancashire and Cheshire, it is inconceivable that academic autonomy will mean any diminution of local interest or pride. Much of the introductory teaching hitherto done at the College will in due course be transferred to other technical colleges in the neighbourhood, leaving the College of Technology as a centre for advanced teaching at degree standard, for training postgraduate students in several branches of technology and for research in these fields. Sir David Eccles himself contemplated this transfer of functions from the regional colleges, and his indifference to academic autonomy and to the views of the professional

institutions may well be a direct consequence of the division of responsibility which leaves university education to the Chancellor of the Exchequer, acting through the University Grants Committee. The need for transferring the responsibility for higher technological education fairly and squarely to the University Grants Committee, or alternatively for creating, as Sir Robert Robinson has been the latest to suggest, a technological grants committee, acting in close co-operation with the former body, but independent and with adequate financial appropriations, could not be better demonstrated.

Nor might this change alone suffice. To remove the responsibility for technical education entirely from the Minister of Education might be too disruptive; but the close relation between technical and technological education, and between the latter and university education, makes it imperative that policy in these fields should not be determined without review at a level high enough to take full cognizance of national needs in respect of scientific and technical man-power. In the existing structure, the Lord President of the Council, with his responsibility for the Advisory Council for Scientific Policy and for the various research councils, seems to be the appropriate Minister, particularly in view of the increasing extent to which the Department of Scientific and Industrial Research is concerned with technical education. The importance of the issues, however, are such that not only should the Minister be provided with an appropriate staff, but also the argument for his being a member of the House of Commons is as cogent as that which requires the Chancellor of the Exchequer to be a member of that body. No Government which is content to allow the Lord President to be answerable to the House of Commons at second-hand through a Treasury spokesman can fairly claim to recognize the over-riding importance of science and technology in Britain's economy to-day.

These issues apart, there was much to welcome in Sir David Eccles's speech of July 21. He not only emphasized that the removal of the critical shortage of scientists and technicians is largely a matter of public education rather than administration—of firing the imagination of school children, their parents, teachers and employers, with the adventure of the scientific revolution; he equally insisted on the importance of general education—of giving better education in all subjects and not just in science and mathematics. The first step is to raise the standards of education in the infant schools, primary schools and secondary schools. Teaching men and women how to enjoy wealth is as important as teaching them how to produce it.

Concluding the debate for the Government, Mr. H. Brooke stated that the Chancellor of the Exchequer has sanctioned a further one million pounds for university development schemes in higher technological education next year. This would virtually complete the programme proposed last year by the University Grants Committee and bring the total Government grant for building schemes outside London to about £4,350,000, which would be increased by equipment and other costs to about £6 million and would necessitate an extra £520,000 for maintenance. Major schemes would be starting in the immediate future in Birmingham, Newcastle on Tyne, Sheffield and Cambridge, and a further set of projects, now in the planning stage, constituted the 1956–57 programme to start at Cambridge, Newcastle on Tyne, Sheffield, Southampton and the Manchester College of Technology.

As regards the Imperial College of Science and Technology in London, expenditure on which in 1953–54 exceeded £1 million, of which almost three-quarters came from the University Grants Committee, Mr. Brooke stated that building work to the value of £4 million has already been authorized, and the developments are expected to cost in all £15 million. The academic staff has already increased from 220 in 1952–53 to 304 in 1953–54 and full-time students from 1,653 to 1,870. While the release of the whole of the South Kensington site involves more formidable difficulties than had been originally appreciated and enabling legislation may be required, neither building work nor academic expansion is being impeded.

Mr. Brooke also pointed out that in the academic year just ended the increase in full-time students of technology and science has accounted for almost the whole of the increase in full-time university students, and he estimated that the number of graduate scientists in the working population of Britain has risen from less than 50,000 in 1939 to nearly 80,000 to-day; for technologists the increase is probably from about 50,000 to more than 130,000; and making no allowance for the expansion of facilities at the universities and technical colleges now in hand, these figures should increase by 1965 to more than 110,000 scientists and about 225,000 technologists. Out of 80,000 scientists, about 25,000 are estimated to be employed in teaching and 10,000 in the Civil Service and allied establishments, about half of whom are in the Defence departments and the Atomic Energy Authority. There are also about 3,000 young post-graduate research workers, and apart from some scientists in the Armed Services, the remaining 40,000 are in industry.

Although these figures were given at the end of the debate, they were obviously known to Sir David Eccles when he said the expansion of the universities would still provide too narrow a route to give us the numbers required, both to push forward the frontiers of science and engineering and to apply them to public service. We must therefore shape the education system of Britain, he said, to supply a very large number of trained men and women in support of the scientists, and for these a much broader route is required than that leading to a university degree. To achieve this he suggested that at all stages there should be young people leaving the local technical colleges and advanced technical colleges for industry and young people coming to the colleges from industry. This would involve a very close partnership between the education authorities and industry, particularly in developing the sandwich courses which the Minister regards as so promising. Moreover, he emphasized that it is equally important not to neglect

the arts and the humanities; we cannot stop the scientific revolution, but it is equally important that men should learn to behave well. There is also a shortage of artists and humanists and men who put spiritual values first, and the educational system must seek to supply these as well as to meet the need for scientists and technicians.

Although the Minister's speech was criticized for not stressing sufficiently the question of quality in relation to science teaching, either in the schools or the technical colleges, and his proposal to institute a new award for technology had a very mixed reception, on the whole his speech was welcomed by the House, which had clearly been deeply impressed by Mr. Albu's remarks on the extent of the actual shortage of scientists and technologists. Mr. Albu had emphasized particularly the implications for the demand for scientific and technical man-power of the development of nuclear energy, the gasification of coal, the modernization of transport, and the needs of the under-developed territories, not only in respect of research, but also, as Sir Ernest Oppenheimer has recently stated, the grave shortages of qualified men in South and Central Africa at all levels and in nearly all industries and Government departments. Mr. Albu's own suggestions, however, notably in regard to the need for ensuring that there is no waste in the use of scientific man-power and that one senior Minister should be made responsible for reviewing the whole problem in the light of changing needs and the present provision for meeting them, met little response in the debate.

One satisfactory feature of the debate is the indication it gives of the extent to which the House of Commons has been impressed by the seriousness of the situation, and the importance of looking at education at all levels and the problem of trained man-power as a whole. Sir Alexander Todd's remarks to the Parliamentary and Scientific Committee as to the need for eliminating the feeling that science, and still more technology, are socially somewhat inferior pursuits, for seeing that children at school are made more aware of the attractions of a career in science, and for reducing premature specialization at school had obviously convinced the Minister and many members on both sides of the House. There was also support for his view that no man can to-day claim to be educated if he knows nothing of natural science, and that besides relieving the shortage of science teachers a general university degree in science would be a more effective means than now exists for producing the men and women with an awareness of science who are needed in all walks of life.

Another important feature of the debate was the general recognition that the shortage of science teachers and the expansion of university and of technological education are only particular aspects of education policy as a whole, and that they are closely related to primary and secondary education. There are, in fact, already facilities for technical training, for example in engineering and in textile technology, which are unused because sufficient young people cannot be persuaded to undertake such studies. On the other hand, there are fields where the number of young people who can be trained is limited by the buildings and facilities that are available; and although the climate of opinion is undoubtedly changing towards careers in science and technology, much remains to be done before existing facilities, and still more the expanded facilities corresponding with Britain's real needs, are fully used.

It is at least encouraging to find that the right questions are at last being asked in Parliament, even to the extent of whether we have the right departmental organization for linking the educational needs of the nation with the actual policy being pursued in universities and technical colleges and by local authorities. The importance of quality and of academic autonomy, the impossibility of developing educational institutions at any level 'on the cheap', the necessity for an overall view and for relating educational policy both to available resources and to the age-structure of the population as well as to the changing needs of the Commonwealth, are clearly appreciated far more widely; and to some extent these needs are over-riding preconceived ideas and party prejudices. Perhaps a greater awareness is needed that a technical college, like a university, is an organic entity, and that it needs a tradition of teachers as well as students if it is to function wel and realize the ideals which, very clearly, many of its principals as well as teaching staff already cherish. That ideal of a balanced education, which turns out experts not merely technically competent but also leavened with imagination and human understanding, will not be achieved simply by more generous support for the technical colleges and the universities. Its fulfilment requires also an educational policy which attempts in the schools themselves to feed the colleges and universities with students whose general education is such that it provides an increasingly effective basis for their further education as professional or technical specialists.

MECHANISMS OF DEVELOPMENT

Analysis of Development

Edited by Prof. Benjamin H. Willier, Prof. Paul A. Weiss and Prof. Viktor Hamburger. Pp. xii + 735. (Philadelphia and London: W. B. Saunders Company, 1955.) 105*s*.

THIS massive volume is one of the most magnificent contributions which American learning has made to the biological sciences for many years. Its aim is nothing less than "to present a modern synthesis of our knowledge of the principles and mechanisms of development". This is a task which has not been attempted, at least in such a detailed fashion, since Schleip's monumental "Die Determination der Primitiventwicklung" of 1929. More recent authors who have given discussions of comparable thoroughness have confined themselves either to particular aspects of the subject, as Needham, Brachet and Barth have dealt with the biochemical mechanisms, or to certain particular groups such as the echinoderms and amphibia in Lehmann's excellent book. The American authors, however,

have covered the whole range of experimental embryology in the broad sense.

"It was evident from the start," the editors write, "that the subject matter had grown in volume and intricacy to the point where it seemed futile for any one individual to attempt to cope with such a task." A short browse through the various chapters will convince even the most self-confident reader that this is true, in the sense that no one man could nowadays possess a critical mastery of all the fields which are included. The battery of experts which has been got together to produce this compilation of knowledge is extremely impressive, and it is seldom one comes across a field which has had to be dealt with by an author who has not made important personal contributions to it. Nevertheless, there are inevitably certain losses to be set against the great advantages which such expertize brings. The editors very disarmingly recognize that "much of the desired unity and integration would be sacrificed, and the present volume bears plainly the stigmata of these imperfections". As a matter of fact, they are too modest. The work is extremely well edited; the individual contributions fit neatly together, with few omissions or overlaps. If the book is to be criticized, it is not for lack of unity or integration at its own level of treatment, but for the absence of a general theoretical scheme which might, as it were, lie behind the details cited in each chapter and provide a framework into which they fitted. Only a single individual author could provide such a scheme, and probably he would have himself to select and arrange the detailed facts which would illuminate it. In spite of the magnitude of the field, there would seem to be, therefore, a place for people bold enough to attempt at least to comprehend, if not to master, the whole of it.

The nearest approach to such a general synthesis is the first chapter, on "Problems, Concepts and their History", by J. M. Oppenheimer. This is a fascinating account of the history of 'embryological philosophy', and one begins to hope that the author will carry on right to the present day, and give us a summary of the ways in which active experimentalists are now picturing to themselves the embryos which they are studying. Alas, she brings her story to a close at about the time of Spemann, and leaves us only with the hint that "the greatest progressive minds of embryology have not searched *for* hypotheses; they have looked *at* embryos". This shirks the crucial issue of to-day, when we are beginning to feel convinced that it is no longer profitable to 'look' at the embryo by anatomical procedures. We seem to be faced with the apparent alternatives of examining it biochemically, or in terms of genetics, or of cell physiology. Which is the more profitable in the immediate future? Or can they be brought together into one broad-fronted line of advance? We are given no direct answer. But the three individual approaches are each separately discussed. F. O. Schmitt and H. Ris contribute extremely stimulating accounts of cell constitution and division. Steinback and Moog give a highly schematized description of cell metabolism, the merits of which I am not qualified to judge. C. Stern discusses gene action in a chapter which, to my mind, is somewhat too influenced by the pre-occupation of geneticists with the question of what a single gene does rather than with the embryologist's problem of how the development of an organ or tissue is influenced by its genotype; it thus overlooks what is perhaps the most important contribution of genetics to embryology, namely, the demonstration that even the simplest developmental process is influenced by an extremely large number of factors.

Of the more conventionally embryological chapters, those by Holtfreter and Hamburger on the Amphibia, Weiss on the nervous system, and Burns on the urogenital system are perhaps outstanding; but there is much else which is first class. The only topics the treatment of which seems seriously inadequate are the insects and the whole problem of the formation of pattern and shape; and one might wish for a fuller account of the recent work of the Swedish school on mitochondria and enzymes in echinoderm embryos. A considerable part of the book is devoted to the later stages of development, which have been passed over rather lightly in most texts.

It is unfortunate, but probably inevitable, that the size of the work will put it out of the financial reach of most individual workers. It is an absolutely essential requirement for all libraries which wish to keep up to date in general biology.

C. H. Waddington

RESOURCES OF THE SEA

The Inexhaustible Sea

By Hawthorne Daniel and Francis Minot. Pp. 239+25 plates. (London: Macdonald and Co. (Publishers), Ltd., 1955.) 16*s*. net.

In the search for further supplies of food for the world's growing population, some attention has been directed to the sea as a potential source of these requirements. The authors of "The Inexhaustible Sea" contend that the sea can do much to meet this need, and can in addition be a valuable source of minerals which are becoming progressively more scarce on land.

Much of this book is a straightforward and very readable account of the exploitation of the sea, from the earliest fishing methods to modern trawlers and whaling factory ships. The beginnings of the science of oceanography are described, together with chapters on the chemical and biological constituents of the sea, food relations in the plankton, and modern fishing and whaling methods. A chapter on new instruments for studying the sea perhaps pays too much attention to echo-sounders and their uses, leaving a mere couple of pages to other methods of research, but in general the authors have covered their subject adequately.

Opinions may differ, however, as to the extent to which the oceans can contribute to man's food requirements. It is true that much progress can be made in improving fishing methods, in the farming of enclosed sea areas, and in the preservation and marketing of fish. But how far will these go towards solving our food problems? The greater part of the globe is covered by sea, but at present only certain areas, mainly on the continental shelves, can be fished economically. In the deep oceans, nutrients are lost from the productive surface layers by the sinking of dead and decaying organisms to deeper layers, and it is only in certain areas where there is upwelling of deep water that nutrients are returned to the surface. In tropical waters the very diversity of species, few occurring in the large shoals found in temperate regions, makes productive fishing more

difficult. Much could be done to popularize the less common species of fish as food: the authors emphasize that only a very few types of fish are to-day widely exploited by commercial fisheries.

Overfishing, a very real problem in certain areas like the North Sea, is given scant attention in this book; and while it is no doubt true that the total production of fish, if it could be exploited, would more than suffice for man's requirements, much of it is not available either because it is in the deep oceans where existing fishing methods are unsuitable, or it is too remote from centres of human population to be harvested economically. Fisheries research has much to contribute to the problem; the sea may be inexhaustible, but is exploitation of the sea on the scale envisaged worth while? Cultivation of the vast barren and desert areas on land would seem to be a more direct and rewarding answer. This book, originally published in the United States, is attractively produced, and is illustrated by some excellent black-and-white photographs. NORMAN HOLME

THEORY OF THE SOLID STATE

Quantum Theory of Solids

By Prof. R. E. Peierls. (International Series of Monographs on Physics.) Pp. viii+229. (Oxford: Clarendon Press; London: Oxford University Press, 1955.) 30*s*. net.

ABOUT twenty years ago when the application of wave mechanics to the theory of the solid state had been investigated in some detail, it appeared that basically all relevant problems except superconductivity had been solved. This stage of the theory bears its fruit now in connexion with many important applications. Many aspects of theory itself based on the earlier pioneer work are being developed at present in minute details. Much of this work, unfortunately, does not appreciate that the theory in its present stage is based on a number of assumptions, and that it has not been possible, so far, to justify all these assumptions in a satisfactory way. It is for this reason that recently a renewed interest in the basic side of the theory of solids has arisen. The difficulties which one faces in this connexion are typical for systems of very many degrees of freedom and are similar to some of the difficulties met in other branches of physics.

In these circumstances it is desirable to have a book which describes the present development of the theory in a simple way without going into too great details, but which clearly points to the assumptions on which the present theory is based. R. E. Peierls's recent monograph fulfils these requirements in an excellent way. The book is divided into eleven chapters, the first three of which deal with atomic vibrations and related processes, whereas the remaining eight chapters are devoted to properties of electrons. A number of subjects, in particular those connected with mechanical and electric strength and with crystal structures, have been omitted from the book; but most of the other important questions are treated, though not all in equal detail. This was necessary in order to restrict the size of the book to about two hundred pages, and the choice of the branches which are treated in some detail must naturally depend on the interest the author has taken in their development. Thus, general questions of electrons in perfect lattices, transport (including heat conduction) and magnetic phenomena are presented more thoroughly than questions of cohesive forces or of the interaction of electrons with light. Even so, the author has found space to impress on the reader the importance of certain effects which are often ignored. This holds, for example, of correlation between electrons, the possible significance of which for optical properties is mentioned, though this has never been properly investigated in the literature. A separate chapter deals with the recent attempts to solve the problem of superconductivity on the basis of the interactions of electrons and lattice vibrations. Both the early success and the later difficulties of this theory are well presented. Recent work on so-called plasma oscillations, which one hopes will help in the treatment of the Coulomb interaction between electrons, has not been included in the book.

The book is mainly addressed to theoretical physicists in so far as it assumes knowledge of the basic methods of quantum mechanics. However, the mathematical treatment is very simple in most chapters, so that the book can be read with profit by the experimentalist who wishes to be instructed on the basis of the models which he is accustomed to use. It is hoped that the book will find a wide circulation, and perhaps sometimes will induce research workers to think before embarking on vast calculations. H. FRÖHLICH

HIGH-SPEED AERODYNAMICS

General Theory of High Speed Aerodynamics

Edited by W. R. Sears. (High Speed Aerodynamics and Jet Propulsion—Vol. 6.) Pp. xiv+758. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1955.) 100*s*. net.

THE present work is Vol. 6 in an ambitious project published by the Princeton University Press in the United States and by the Oxford University Press in Britain under the general title of "High Speed Aerodynamics and Jet Propulsion". The whole work is to be completed in twelve volumes and is to cover the related fields of gas dynamics, aerodynamics, combustion and jet propulsion. The editorial board which is responsible for the general supervision of this work consists of Theodore von Kármán, Hugh L. Dryden and Hugh S. Taylor. The work has been in progress for some years and, in fact, the formal establishment of the Aeronautics Publication Program took place at Princeton University in the autumn of 1949. In this connexion it may be as well to mention one minor criticism of this great and important work, namely, it is sometimes a little difficult to determine the date on which the different contributions to this volume were completed, and therefore difficult to know exactly how recent is the information which is presented. Another comment which is suggested by the fact that this volume, numbered 6 in the series, is the first to be published, is that the present volume is not self-contained and there are references to work which is to be published in Vol. 3; for example, Crocco's stream function is referred to in the present volume, but the reader is referred to Vol. 3 for a formal definition of this important concept. Questions of priority of publication and discovery are not considered in this treatise, which indeed makes no pretence of being absolutely complete. Considerations of space themselves have set an inevitable limit to the amount of work which is included.

Having made these few critical comments, the reviewer would like at once to pay tribute to the great value and importance of this project. It will provide the aerodynamicist and the aeronautical engineer with what is almost an encyclopædic account of the basic information which has been obtained in the past ten years or so in this most fascinating and vitally important subject; and it will incidentally be of great benefit to the individual research worker, who will be able to throw away some dozens, if not hundreds, of offprints and government reports, now that he has the admirable summaries and critical appreciations which are contained in this volume.

Seven authors have contributed to this volume, which is edited by W. R. Sears. Von Kármán writes on the foundation of high-speed aerodynamics, Friedrichs on mathematical aspects of flow problems of hyperbolic type, Sears on small perturbation theory, Heaslet and Lomax on supersonic and transonic small perturbation theory, Lighthill on higher approximations in both subsonic and supersonic flow; Kuo and Sears have collaborated in a chapter on plane subsonic and transonic potential flows, while Ferri has written two chapters, one on the method of characteristics and one on supersonic flows with shock waves.

The introductory section by von Kármán gives a general account of the linearized theory of aerodynamics, with especial reference to its limitations. This chapter also contains a general introductory sketch of fluid dynamics in the hypersonic range and in the transonic range. The next chapter, by Friedrichs, is almost entirely concerned with problems of the mathematical theory of the differential equations of unsteady one-dimensional flow and of two-dimensional steady flow. Friedrichs gives a careful analysis of what is required in order that these problems should be correctly set, and of the validity of the various idealizations which are contemplated in the mathematical theory.

After traversing the familiar ground of the small perturbation theory due to Prandtl and Glauert, Sears describes the slender-body theory of Munk and Jones and gives a brief review of unsteady flow problems.

These introductory sections cover about 120 pages, and we now come to a long section by Heaslet and Lomax, which occupies about two hundred pages. This chapter opens with a discussion of the wave equation and of some methods of solution. The authors concentrate on the method due to Volterra, although the work of Hadamard is referred to later. They then proceed to discuss standard methods for dealing with problems of two-dimensional steady flow and of three-dimensional steady flow. There is a most useful collection of formulæ and a discussion of the singular integral equations which arise in this part of the subject. In practice, the 'null' transforms which are needed to solve the singular integral equations seem to be obtained by intuition rather than construction. These theories are applied to a number of inverse problems and also to generalized conical flow. The authors then discuss axially symmetric supersonic steady flows and point out the interesting duality between the expressions for the drag of a body of revolution and for a wing of finite span. This is followed by an excellent chapter on slender-airplane theory and by another chapter on the theory of unsteady lift. In this chapter the indicial functions which are fundamental to the topic are quoted but not derived. There is, however, a discussion of the evaluation of the starting lift coefficient which will probably be found more illuminating than in the original paper in which it was first announced. The next chapter deals with reciprocity relations based on Green's reciprocal theorem and on reverse flow theorems. This great section closes with an account of small perturbation theories and transonic and hypersonic flows.

The next section, by Lighthill, covers about 140 pages and deals with the difficult and important problem of obtaining higher approximations to the non-linear equations of fluid dynamics. Although it is invidious to single out for especial mention any one section in this excellent work, it does seem to the reviewer that this is probably the most important section of the whole volume. Lighthill not only gives a very complete and critical account of the older second-order theories of subsonic and supersonic flow, but also gives a stimulating account of the recent work by Whitham himself on the nature of the flow pattern at great distances from an aerofoil or missile. Of all the sections of the book, this one seems to stand out by reason of its continuous appeal to physical concepts and to the new mathematical methods introduced.

In the following section, Kuo and Sears give an account of the hodograph theory due to Chaplygin, together with its simplification by Kármán and Tsien, and to the important, fairly recent developments by Lighthill and Cherry. The ninety-odd pages of this chapter flow with the most valuable summary of formulæ embodying the main properties of the hypergeometric functions which are employed in the solutions of the hodograph equations.

The following chapter, by Ferri, gives a masterly account of the method of characteristics both in two-dimensional potential flow and in axially symmetric flow, while further chapters show how proper allowance can be made for distributed vorticity and for extensions to problems involving three independent variables. Finally, the author discusses the linearized characteristic equations in which one of the velocity components or its variation can be considered small. As a natural sequence, in the concluding chapter Ferri discusses the general theory of shock waves in two-dimensions and in axially symmetric flow; and then passes on to discuss the same problems in transonic flow and in conical flow. These chapters will be most useful to all those who are engaged in the numerical solution of supersonic problems. There is one sentence on p. 587 which reads very strangely, in which Ferri says that "the velocity of sound a for the general case depends on the direction of the line along which it is computed". This should be read in conjunction with the careful analysis which Lighthill has given of the physical significance of the fundamental equations, and in particular in connexion with the basic relations, numbered 5 and 6, which Lighthill gives on p. 347.

The publication of this volume is the most important event in the world of aerodynamics since that of the volumes on high-speed flow under the general title of "Modern Developments in Fluid Dynamics" (Clarendon Press, Oxford, 1953). There can be no doubt, too, that this volume, together with its companions, will for some time to come be the standard work of reference; and all students of aerodynamics will be immensely grateful to the editors and contributors who have collaborated to produce this great work.

G. Temple

Oil in the Middle East

Its Discovery and Development. By Stephen Hemsley Longrigg. Pp. xiii+305. (London: Oxford University Press, 1954. Issued under the auspices of the Royal Institute of International Affairs.) 25*s*. net.

THIS is essentially not a technical but a historical survey of Middle East oil. Scarcely anything like it has previously been published, at least for this region of oil-producing territories. The author, executive of one of the chief operating companies, has been connected with the Middle East professionally for nearly forty years (twenty-five as resident); he writes with authority and inside knowledge of men and organizations responsible for developing vast petroleum resources of Persia, Iraq, Levant and Arabia, from small beginnings to their present magnitude.

The background to these chronicles is essentially political and economic: sometimes there is peaceful co-existence between them; occasionally decidedly the opposite is portrayed, for example, in his lucid chapter "The Tragedy of Persia", one of the best objectively written accounts of what nationalization of that country's oil really meant to Britain, and still implies. The whole story of fortunes and misfortunes of Middle East oil is vividly unfolded, from early days in the nineteenth century; before, during and after the First World War; between the Wars; and the Second World War and since. The parts played by all-American and international companies (1946–53) are not the least enlightening and valuable sections of the book.

While it deserves a conspicuous position in all libraries of the oil industry, this book will especially appeal to executives and others who have devoted their lives (and to those who still do) to founding, expanding and administering huge international petroleum undertakings, not only in the Middle East but also in other parts of the world where oilfield developments are on a comparable scale. H. B. MILNER

Birds as Animals

1: A History of Birds. By James Fisher. (Biological Sciences.) Pp. 208. (London: Hutchinson's University Library, 1954.) 8*s*. 6*d*. net.

THIS work is based on the author's "Birds as Animals", rewritten and enlarged, and is intended as a general introduction to ornithology for university students. Owing to the small size of the book, it has only been able to give a brief survey of the various aspects of the subject; but nevertheless it is a useful summary of what is known. For those who wish to pursue the subject further, there is a voluminous bibliography at the end of the book.

The first three chapters are devoted to an account of the early bird historians and more important writers, based on Newton's "Dictionary" and Cassey Wood's two volumes, which last mention several authors not available to Newton. Systematics and bird specification are dealt with in separate chapters and might well have been combined, and the same may be said of that devoted to bird history, by which the author means the geological history of birds. It is difficult to treat these subjects separately without a good deal of overlapping. In the chapter on geographical distribution we have interesting accounts of some of the birds met with by early visitors to the Americas; but there is rather a dearth of information in regard to the East Indies and Australia. The long account of Audubon and his works might well have been replaced by more information on the birds discovered by Cook. The number of birds is a subject to which the author has paid much attention, and accordingly he devotes a chapter to tell us what he knows. Finally, there are chapters dealing with cycles, changes in numbers and the effect of man on bird populations. N. B. KINNEAR

An Introduction to Plant Physiology

By Dr. W. O. James. Fifth edition. Pp. viii+303. (Oxford: Clarendon Press; London: Oxford University Press, 1955.) 17*s*. 6*d*. net.

THIS well-known and highly esteemed little book is now brought up to date by the incorporation of new material on respiration, photosynthesis, mineral nutrition, hormones, and other aspects. The insertions have mostly been woven skilfully into the older text, though a contrary instance is the inclusion of two rather different accounts of axillary bud dormancy. The mechanism of nitrogen fixation is not now so unelucidated as the author suggests.

A few minor weaknesses persist from earlier editions; thus two different formulæ are still given for preparing molar sucrose, without explanation (and it is now implied, erroneously, that the osmotic pressure of a weight-molar sucrose solution is 34·5 atmospheres). The unqualified statements that wheat grains have never been found to survive for more than sixteen years and that the *Calluna* mycorrhiza fixes nitrogen could be questioned.

For much the greater part, however, the text has the stamp of authority, and where finances permit the elementary student of botany to acquire textbooks limited in scope to a single branch of the subject, this one can be strongly recommended. A first reading yielded four misprints only. G. BOND

Elementary Qualitative Analysis on the Small Scale

By Dr. Peter Woodward. Pp. viii+92. (London: Oxford University Press, 1955.) 12*s*. 6*d*. net.

THIS essentially practical manual for sixth-form pupils and university freshmen deals with the analysis of simple mixtures of salts soluble in acids. The first of the text's five parts contains an advocacy of small-scale methods; the second describes the apparatus required and techniques recommended; the fourth deals with the chemistry of the separations and the fifth with the analysis of more difficult mixtures of anions. Although in general the schemes of analysis (Part 3) are on familiar lines, the book is unusual in its content.

Thus the author has omitted the customary long lists of reactions of the ions concerned; his outstanding contribution is the introduction into school practice of some of the new methods and principles which are revolutionizing qualitative analysis. One example must suffice—the passage of hydrogen sulphide under pressure. Dr. Woodward uses, not the elaborate apparatus described in most books but a small flask attached to an ordinary Kipp's apparatus. The reviewer can testify to the efficacy of this procedure and to the pleasure with which pupils adopt it.

With a touch of genius the author has added appendixes describing: the separation of cobalt and nickel by paper chromatography and the removal of phosphate by exchange adsorption, thus affording exercises for the abler pupils and indicating the way analysis is developing. The methods herein described should come as a boon to teachers and should help to promote a happier presentation of analysis.

G. FOWLES

THE PEACEFUL USES OF ATOMIC ENERGY

THE GENEVA INTERNATIONAL CONFERENCE

By Sir JOHN COCKCROFT, K.C.B., C.B.E., F.R.S.

THE Geneva Conference on the Peaceful Uses of Atomic Energy organized by the United Nations Organization has been a remarkable experience for those fortunate in participating. It was attended by 1,400 delegates and observers from seventy-three countries. More than a thousand papers were prepared for the Conference, of which 450 were read.

The more general topics such as the future requirements for energy and the role of nuclear power were discussed in three days of plenary sessions. This was followed by nine days of technical discussions going on from 9 a.m. to 5.30 p.m. in three parallel sessions for reactor technology, chemical and metallurgical technology and biology and isotopes. Adequate time was allowed for presentation of the papers, which were simultaneously translated into four languages, and discussion periods of ten minutes or so were fully used.

Besides these, innumerable detailed discussions proceeded in the broad corridors of the Palais des Nations, which is conveniently provided with comfortable seats ideal for such a purpose. Advantage was also taken of the unique gathering of distinguished scientists to arrange many informal seminars. Thus a whole-day seminar on field theory was attended by theoretical physicists from the United States, the United Kingdom and the U.S.S.R. and many other countries, and was the first occasion on which Russian and Western physicists have met for discussion of this subject since 1937. Prof. E. O. Lawrence and Prof. V. I. Veksler attended seminars on high-energy accelerators following the evening lectures which they gave on their own accelerator work. The scientific and technical activities were supplemented by innumerable receptions, lunches and dinners, so that every available minute was occupied from 9 a.m. until midnight, and the Conference was a test of physical fitness unparalleled in our experience.

The main weight of the papers in the sessions on reactor technology and chemical and metallurgical technology came from Britain, the U.S.S.R. and the United States, though there were many valuable contributions from other countries. The Conference led to a lifting of the veil over the atomic energy programme of the U.S.S.R. and coincided with the coming into effect of a revised declassification policy of Britain, Canada and the United States, decided in principle nine months ago.

So we heard a large number of valuable papers on research reactors and power reactors and their associated technology. From the nine hundred or so possible types of power reactors in Dr. A. M. Weinberg's classification, about twelve have been selected for construction in experimental or prototype form by five nations. Thus graphite-moderated reactors using gas, water or liquid sodium for cooling are being built by Britain and France, the U.S.S.R. and the United States, respectively.

Water-moderated reactors using solid fuel are being studied in four types using light or heavy water, and in designs in which the water boils and is transmitted direct to a turbine or in which the water circulates through a heat exchanger to raise steam. Homogeneous thermal reactors were described in at least three forms, while experimental fast reactors are being built by both the United States and the United Kingdom.

Prof. D. V. Blokhintsev, who is head of the Institute of the Academy of Sciences of the U.S.S.R. devoted to reactor development, described the first Russian water-cooled graphite-moderated power station, which has been operating for a year and produces 5,000 kilowatts of electricity. The power reactor was designed on severely practical lines with no regard for neutron economy, since uranium fuel containing 5 per cent of uranium-235 enclosed in stainless steel tubes constitutes the fuel element. So fuel costs are very high, and the regeneration of secondary plutonium fuel is low. The reactor has proved to be very reliable in operation and is providing experience from which a 100-megawatt reactor is now being built. This reactor will also use highly enriched fuel and is expected to produce power at a cost of 10–20 kopecks per unit, as compared with an average price for conventional stations of 10 kopecks. Other types of power reactors are being experimented with, including fast reactors; but the state of development appears to be behind American and British progress.

The American papers on power reactors and nuclear technology show a very broad development in this field. Very detailed papers were presented on the American pressurized water reactor which is to develop more than 60 megawatts, the sodium-graphite reactor developing 75 megawatts, the boiling heavy-water reactor developing 180 megawatts, the homogeneous aqueous and liquid metal-fuelled reactors and the sodium-cooled 62-megawatt (fast) experimental breeder reactor. These papers were supplemented by most interesting models in the exhibition at the Palais des Nations, together with specimens of the fuel elements to be used.

These reactors form part of the American five-year programme of experimental and demonstration power reactors which will be completed by 1960, so that by then the United States will be generating 700 megawatts of electricity from nuclear stations.

Britain presented papers on the engineering details of the Calder Hall graphite-moderated gas-cooled reactor and the Dounreay fast reactor. Models of these reactors were shown in the exhibition, together with a most interesting colour film on the building of the Calder Hall reactor. Britain also contributed many papers on reactor technology. One of the most interesting described the results obtained with the zero-energy fast reactor—ZEPHYR—which showed that in a plutonium-fuelled zero-energy fast reactor, for each plutonium atom destroyed in the core, two new plutonium atoms are produced in the blanket. Fission of the uranium-235 in the blanket plays an

important part. The full-sized fast reactor will not realize the full theoretical breeding gain, owing to absorption of neutrons by coolant and other materials. Nevertheless, high-gain factors seem assured, and Dr. W. H. Zinn predicts a breeding gain of 60–70 per cent with the American plutonium – uranium-238 experimental breeding reactor, leading to a time to double the fuel investment of five to six years.

The aqueous homogeneous breeding reactor using the thorium – uranium-233 fuel cycle was predicted to have a breeding gain of 10–15 per cent, together with very high outputs per kilogram of fuel and comparatively low capital costs. The uranium-238 – plutonium fuel cycle does not promise breeding in the thermal region. Since thorium has also favourable properties metallurgically, its use in thermal reactors seems likely to be generally important in the second decade.

Our best view of Russian nuclear technology was in the field of nuclear constants. The nuclear data obtained by the U.S.S.R., Britain, the United States and France have all been plotted on a common basis and show very good agreement, showing that Russian techniques and instruments are as highly developed as those in Britain and the United States.

The papers on the economics of nuclear power showed a general consensus of opinion that capital costs of nuclear power stations will be appreciably higher during the next decade than those of conventional power stations. Typical values were £120 per kilowatt for a 150-megawatt gas-cooled graphite reactor; 250 dollars per kilowatt for a 250-megawatt heavy-water reactor; 200 dollars per kilowatt for a 75-megawatt sodium-graphite reactor. The first figure is based on the construction cost of Calder Hall; the last three on design studies only. Fuel costs were predicted to be lower than for conventional stations; but this depends largely on the 'burn-up' of the uranium-235 which is achieved. Prediction of heat extraction per ton of uranium varied from the equivalent of 10,000 tons of coal to more than three times this figure. But little experimental evidence is yet available.

The figure for the overall cost of nuclear power depends a great deal on the interest rate assumed. The Americans use high capital charges—of the order of 12 per cent—and their forecast overall production costs during the next decade lie between 7 and 10 mills, while the great bulk of their power is generated at about 5 mills. In Britain nuclear power is quasi-competitive.

The forecasts of the proportion of electricity to be generated by nuclear power in 1975 varied, from 40 per cent in Britain to an American figure lying between 1 per cent and 15 per cent, depending on whether costs are 9 mills a unit or 6 mills a unit at that time. The Canadian position seems to be rather similar. Forecasts of the usage in other countries by 1975 varied greatly, depending on the amount of hydroelectricity still to be developed and its capital cost and location. Most Western European countries will not require appreciable amounts of nuclear power before 1965.

Dr. H. J. Bhabha's paper on India's energy requirements showed that 80 per cent of the energy comes from the burning of dung. The energy consumption per head is one-tenth of that of Britain, and electricity consumption one-eightieth. This is planned to increase seven-fold by 1975, so electrical capacity will have to increase from 3½ million kilowatts to 25 million kilowatts. The undeveloped hydroelectric capacity of 35 million kilowatts could provide most of this; but there are some areas far from hydroelectric sources where thermal power stations are at present used, and here nuclear energy will play a part. India is especially interested in the use of thorium.

Papers on the power requirements in other 'under-developed countries' showed a need for power reactors developing about 10 megawatts of electricity. These may also find applications in remote mining areas. Power costs in many of these areas are already much higher than normal costs—up to four times higher. Power from small units will necessarily be higher in cost; but papers presented by the United States suggest that a reactor of the boiling-water type could probably produce power at 15 mills, which is almost competitive with commercial 10-megawatt power stations.

It appears, however, that a much more detailed 'market survey' of the power needs and requirements of these countries is required before we can assess the volume of applications in the next two decades.

The position at the end of the century is easier to assess, since the economists and statisticians agreed in predicting a minimum energy requirement of 7 or 8 billion tons of coal-equivalent by the year 2000, of which half would be required for generating electricity. Hydroelectricity is predicted to supply 1 billion tons equivalent, and it is hoped that nuclear energy would by then be able to do the work of 2–3 billion tons of coal a year. The forecast of British requirements for nuclear energy at that time is about a tenth of this figure.

Papers on the occurrence of uranium and thorium suggest that in the 1960's plenty of fuel will be available at a cost of about 10 dollars a lb. Supplies of at least one million tons were reported to be available and, if by the end of the century breeding is achieved, only a few thousand tons of uranium and thorium a year are required to undertake the predicted task of the economist.

The biological sessions discussed the hazards of radiation to workers in the atomic energy industry and to the general public. The excellent work done by the International Commission on Radiological Protection in determining safe levels of radiation and safe amounts of radioactive materials was described, and it was agreed that these recommendations ought to be incorporated into world-wide codes of practice. The World Health Organization undertook to help countries new to atomic energy development. The genetic problems of radiation were also discussed in brief sessions, and there was agreement about the inadequate experimental data and the need for increasing the scale of experimental work. Besides the United States and Great Britain, several other countries will undertake experimental work. The work is, however, expensive, and may easily cost £100,000 per annum if significant results are to be achieved within ten years.

Numerous papers were presented describing the applications of radioactive isotopes to biology, medicine and industry.

An interesting picture of the state of development of Russian pure nuclear physics was revealed by Prof. Veksler's evening lecture on high-energy particle accelerators. The U.S.S.R. now have the highest-energy synchro-cyclotron in the world—producing 660-million volt protons. They have also nearly completed a 10-billion volt proton synchrotron. This accelerator is of a similar design to the

Berkeley 6-billion volt bevatron. It uses 36,000 tons of steel in a magnet having an air gap of 2 m. × 40 cm.; so for the next three or four years the U.S.S.R. will have more powerful machines than the United States. Britain is now far behind both countries in its equipment and work in this most important field of nuclear physics.

In general, we have gained the impression that the U.S.S.R. have an enormous deployment of scientific effort in the field of atomic energy, and that their output of scientists and technologists from their universities is quite adequate to maintain this without starving other activities.

The Conference has been more successful than we had dared to hope from such a large gathering. It has brought together East and West after a long period of separation in the physical sciences. It has been a meeting ground for innumerable friends from all parts of the world. It has enabled us to discuss how best we can help other countries, and has done a great deal to re-establish the normal pattern of communication in the scientific world.

THE CULCHETH LABORATORIES OF THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY INDUSTRIAL GROUP

By Dr. A. B. McINTOSH

THE White Paper, "A Programme of Nuclear Power" (Cmd. 9389), has directed attention to the work of the Atomic Energy Authority composed of the Weapons Group (A.W.R.E.), the Research Group (A.E.R.E.) and the Industrial Group. Each is represented by a member of the executive under the chairmanship of Sir Edwin Plowden.

Under Sir Christopher Hinton, its managing director, the Industrial Group is responsible for the design, construction and operation of plants for the production of fissile material and for the prototype nuclear power stations at Calder Hall and Chapel Cross. It is also responsible for advice and guidance to the industrial firms which will undertake the construction of the power stations for the Central Electricity Authority proposed in the White Paper. In collaboration with Harwell, it also pioneers new types of reactors in conformity with the policy laid down in the White Paper.

Within the Industrial Group there are three technical branches: Engineering, Operations, and Research and Development, each under its own director. The design and construction of such projects as the reactors at Calder Hall, Chapel Cross and the large experimental fast reactor at Dounreay are the responsibility of the Engineering Branch. On completion of the plants, the Operations Branch becomes responsible for operation and level of production.

The responsibility of the Research and Development Branch under its director, Mr. L. Rotherham, is: (1) removal of difficulties which may impede the attainment of full production in any part of a production plant and the development of works processes; (2) provision of information to support the design of new plants and prototype reactors; (3) longer-term study of problems which arise from production plants and design studies.

The Branch works in close collaboration with the Research Establishment at Harwell, which undertakes part of the work.

In the Research and Development Branch, the emphasis is always on the technique at a particular date, and all work is planned and progressed in the same way as the engineering construction programmes to which the major part is intimately linked. It is research applied to industrial needs and not pure research, but in all its work there is close co-ordination and collaboration with the Research Group at Harwell. This is especially important in the earliest stages, when the feasibility of future reactor systems is being studied.

There are at present four laboratories in the Research and Development Branch, with a fifth in course of formation for work on the Dounreay site. In each of the laboratories there is a large measure of local autonomy and authority. At the Industrial Group Headquarters at Risley there is a section of the Research and Development Branch working in close collaboration with the design engineers and the headquarters organization of the Operations Branch. Part of the responsibility of this section is that of carrying out theoretical calculations for the four existing laboratories at Capenhurst, Windscale, Springfields and Culcheth.

Except for some specialized fields in which Harwell is responsible, these laboratories, with a scientific and experimental complement of approximately eight hundred, provide a development effort for sanctioned construction projects which are the commitments of the Industrial Group. The Capenhurst Laboratory deals mainly with problems of an engineering nature, such as fluid flow and heat transfer. At Windscale the laboratories are largely devoted to radioactive chemistry, metallurgy and physics, arising from reactor problems at Windscale and Calder and the chemical problems of the plutonium separation process. In Culcheth there is a responsibility for the selection of reactor materials and for work on the extraction of these materials where they may not be commercially available. The small-scale work carried out at Culcheth is then extended to a larger scale at the Springfields Laboratory, which is responsible for the development of fuels and fuel elements.

Culcheth is the only laboratory not on a works site; but it is associated very closely with the Engineering Design Branch at Risley. This gives the laboratories a responsibility for the initiation of work at the feasibility and planning stage of new reactors, especially in the selection of materials for reactor components.

To carry out the commitments of the White Paper, increases in staff in the Research and Development Branch of the Industrial Group are necessary. The Culcheth Laboratories have a present complement of approximately 160 scientific and experimental staff. They are extensively equipped with all the tools required for modern metallurgical research and include laboratories specializing in X-ray diffraction techniques, electron microscopy and ceramics. How-

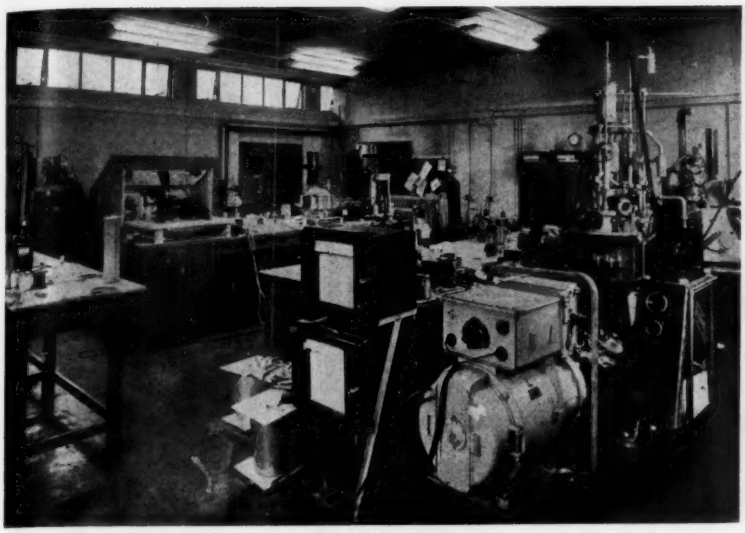

Fig. 1. Metallurgical Laboratory, Culcheth

ever, apart from the large Creep Section and the Materials Inspection Group, both of which have rather special functions, the work of the remainder of the Laboratories is organized to produce results by a planned date for the main programme of engineering construction projects. The objectives of the projects are in all cases the furtherance of the programme of nuclear power development outlined in the White Paper and the development of prototype reactors.

From an overall view, many problems of nuclear power production in the various types of reactor, whether fast fission, thermal or homogeneous, present a common basis. The main questions are of compatibility of materials, the winning of selected metals, the physical metallurgy of chosen alloys and the deformation of metals both in fabrication and under irradiation.

Fuels. When uranium is irradiated, it undergoes dimensional changes which, if sufficiently large, impose stresses on the fuel container. Similar changes are produced by thermally cycling the material, particularly if the cycle includes a phase transformation. These changes affect the life of the fuel elements adversely and limit the operating temperature and the rate of operation of the pile. To achieve the enhanced efficiency and lower production costs visualized in the White Paper, work is in hand to limit these two forms of irradiation damage.

Two possible methods of reducing irradiation damage are by alloy additions and by suitable heat treatment. The former necessitates manufacturing techniques which are complicated by the extreme chemical reactivity of uranium. These techniques include vacuum or inert atmosphere arc melting, melting by electron bombardment and powder metallurgy. The latter methods are particularly appropriate for the production of fuels which are permeable to gas, a property which may be desirable. It is worth recording that all melting equipment used at Culcheth was designed and built in the Laboratories and includes two d.c. arc furnaces operated from welding generators. An electron-bombardment furnace of novel design will be operating in the very near future.

Once the alloys have been prepared, physical and mechanical properties such as thermal conductivity, thermal expansion, creep strength and permeability to gas are measured. The behaviour of the material under various thermal cycling treatments is determined. In those cases where the fuel may come into contact with the coolant, suitable corrosion tests assess the compatibility.

Canning materials. The economic production of electrical power from nuclear reactions demands the highest efficiency at all stages of operation. These demands are made not only on the reactor fuels, but also in the associated components such as the cans which contain the actual fuel.

In thermal reactors the number of spare neutrons is so small that the paramount requirement for canning materials is that they should have small capture cross-sections for neutrons. If these conditions are to be fulfilled, the most desirable elements for canning include aluminium, beryllium, magnesium and zirconium. These metals do not, however, possess all the other required properties, and work is in progress to assess the improvements which may be achieved by the addition of minor alloying additions to the parent metals.

In fast reactors, the necessity of minimum absorption of neutrons is less important and must be balanced against the need for a metal which can withstand as high a temperature as possible. This focuses attention on the refractory transition metals such as titanium, zirconium, vanadium, niobium, tantalum, molybdenum, tungsten and rhenium. Of these metals, titanium has received considerable attention in recent years as a constructional material, and some of the others have been the subject of research, while most have been used in the form of ferro alloys for additions to steel. At Culcheth, methods have been developed for the extraction of some of these metals in a very pure state, and, for the first time in Britain, vanadium and niobium have been prepared in a ductile form. Techniques have also been devised for the fabrication of these materials, and determinations have been made of their physical and mechanical properties.

It has been found that in some cases a metal or alloy which in other respects possesses highly desirable properties has to be rejected because it reacts with uranium at the appropriate reactor-operating temperature. Methods under investigation to overcome this problem include the deposition of refractory metals from volatile compounds and the use of oxide coatings to separate the fuel from the can.

Breeder materials. In order to maintain and improve stocks of fissile material and to take full advantage of the new types of reactor which promise

Fig. 2. Creep Laboratory, Culcheth

to be made available as a result of experimental work at Dounreay, it is essential that fresh supplies be obtained by 'breeding' or converting suitable elements. Two such elements are thorium-232 and uranium-238 which, under irradiation, absorb neutrons and then undergo radioactive decay to yield the two fissile materials, uranium-233 and plutonium-239, respectively. The Research and the Industrial Groups have been examining the economic prospects of thorium reactions and, at Culcheth, in view of the success in the preparation of refractory metals by various methods, similar processes are being examined for the extraction of thorium from monazite.

Coolants. The coolant is the all-important medium through which the heat developed in the core of the reactor will be removed to generate the required steam pressure in the heat-exchanger. Coolants which may be employed in nuclear reactors include water, gases and liquid metals. Not only must the corrosive behaviour of a coolant be investigated, but also many other of its chemical and physical properties, depending on the particular application. As an example, the Dounreay reactor is likely to employ a liquid-metal coolant in the form of sodium–potassium alloy. For this and other liquid metals considered, precise knowledge of ignition temperatures is essential if an accurate estimate is to be made of any hazard which they may present. This ensures that the safety precautions installed are adequate without being excessive and uneconomical.

Constructional materials. The Atomic Energy Authority's products are such that to contain or process them constructional materials must have, in addition to their normal properties, some feature such as resistance to corrosion in conditions where this is more than usually severe, or where loss by pick-up of a valuable process gas must be avoided. Work is constantly in progress at Culcheth on the examination and improvement of plant materials by the development of new alloys or superior manufacturing techniques. This work frequently results in a combination of reduced capital and running costs with an increase in the technical efficiency of a process.

Materials Inspection Group. In any large organization, it is essential that routine tests should be made to ensure that all materials employed are of suitable quality. This service to the Inspection Branch is carried out by a section which also acts as a works metallurgical laboratory for some sections of the Industrial Group. Engineering parts which have received particular attention are brass bellows, water-coolers and bearings.

Creep. The Culcheth Laboratories possess the only creep-testing facilities in the Atomic Energy Authority, and extensive tests have been carried out in inert atmospheres, on a scale probably larger than any attempted elsewhere in Britain. It is believed that, previously, the usual type of precision mirror extensometer had not been used for routine creep tests of materials requiring protection from atmospheric attack, as an enclosed extensometer requires some device whereby, during the course of the test, the mirrors may be reset without breaking a gas seal. The Laboratories have, however, designed, built and successfully operated enclosed mirror extensometers of this type. Materials tested include specimens of proposed canning metals and of uranium itself. Creep-testing machines have also been used for stress-relaxation tests on specimens of the all-welded steel structure of the pressure shell of the thermal reactor under construction at Calder Hall.

Long-term studies as carried out in the Physical Metallurgy and Creep Laboratories aim at providing the basic information for the development of fuels, canning alloys and materials of construction for advanced types of reactors. Fundamental research

in the Creep Laboratories is at present directed towards the hardening properties of solid solutions, based on aluminium–copper alloys. Starting from this simple alloy, additions of elements with different electron configurations and differing atom sizes can be examined. From this it is hoped to deduce the relationship between the size of the atom and the electron structure, the consequent effect upon hardening and ultimately the creep-strength. Results obtained from a simple alloy should be applicable to the development of reactor materials.

In the long chain of development between the concept of a new reactor and its operation, the Laboratories at Culcheth with their specialized interests in chemistry, physical chemistry and deformation of metals provide an important link.

THE PLANT BREEDING INSTITUTE, CAMBRIDGE

ON July 15 the new buildings and experimental grounds of the Plant Breeding Institute, Cambridge, were officially opened by Mr. D. Heathcote Amory, Minister of Agriculture, Fisheries and Food. The guests of the governing body included the Vice-Chancellor of the University of Cambridge, the Mayor of Cambridge, the City Parliamentary member, officials of the City and County and representatives of the Agricultural Research Council, the Ministry of Agriculture, the National Agricultural Advisory Service, research institutes and university departments.

In his opening remarks the chairman of the governing body, Sir Frank Engledow, paid tribute to the classic work on genetics and plant breeding of the late Sir Roland Biffen, the first director, whose early researches not only stimulated the development of genetic science and its application to the improvement of agricultural plants, but also resulted in the foundation of the Institute in 1912 at the University School of Agriculture. Biffen's work was essentially that of a great individualist who was among the first of the few scientists to appreciate the epoch-making significance of Mendel's genetic work. But Biffen's scientific acumen and imagination led him to apply the new knowledge to crop improvement, and he chose wheat on which to experiment and test the validity and value of the new knowledge. This started a new era in plant breeding, and the work at the Institute developed considerably under its two succeeding directors, with the ultimate establishment of the present greatly enlarged research centre.

The Minister, in declaring open the new buildings, said the occasion was significant in marking the fruitful collaboration of agriculture with Cambridge scientists. He welcomed the closer association of scientific research with the task of improving the productivity of British agriculture, and mentioned the great work that had been done in recent years in increasing the output from the farms of Great Britain. He emphasized the great importance that the Government attaches to agricultural research, and stated that although there has been a recent change in the administration of this research through transfer of control to the Agricultural Research Council, this would not mean any lessening of the Government's interest and support; he, himself, would continue to have the closest association with research work through the Privy Council committee dealing with this important matter.

The director of the Institute, Dr. G. D. H. Bell, coupled his thanks to the Minister with acknowledgments to all who had helped in the task of establishing the Institute in its new home, finally separated from the University. He paid especial tribute to Sir Frank Engledow, not only for his important scientific work in the Institute, but also for his valuable help and guidance, together with that of

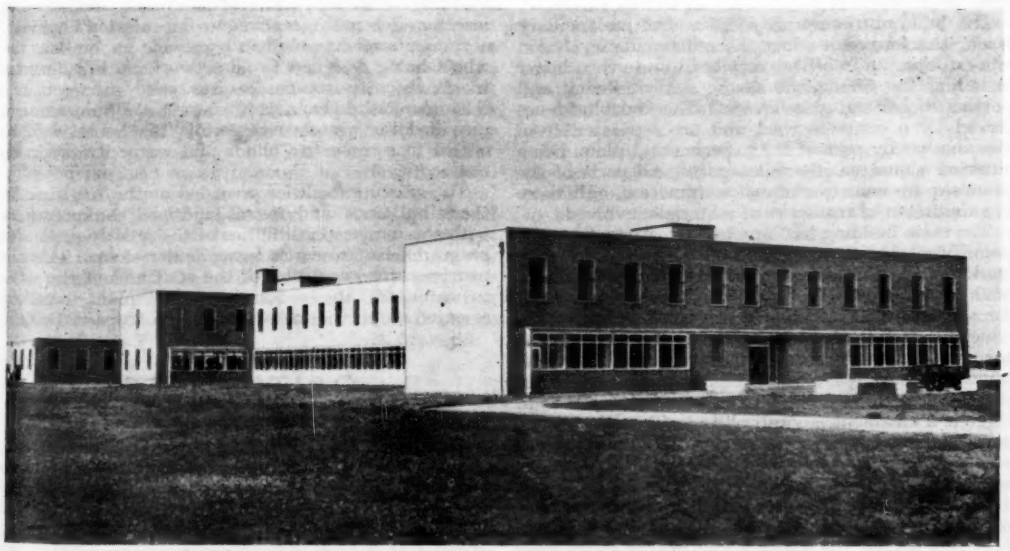

Fig. 1. Plant Breeding Institute, Cambridge, showing the main entrance to the building (right) and the range of laboratories extending from it

members of the governing body. There was much to do, and in developing both fundamental and applied research for the improvement of crops, he saw a satisfying task for his colleagues and himself. There must be the closest integration of science and agriculture, and the facilities which have been provided for the Institute gave the greatest opportunity for those engaged in contributing to scientific knowledge and in breeding improved varieties of crops.

The new premises of the Institute are situated on Anstey Hall Farm, Trumpington, some 2½ miles to the south of Cambridge, and adjacent to the headquarters of the Eastern Province of the National Agricultural Advisory Service. The situation is not only appropriate for a research station that is to devote its attention to the arable crops of the drier parts of England, but it also makes possible the continued close liaison with the School of Agriculture of the University, as well as ensuring easy association with other University departments. Consequently the Institute is able to contribute to the teaching in the University, while it also has the inestimable benefit of close association with the research workers in various University departments.

The Trumpington premises have been planned so that the laboratories, offices, glasshouses and all other facilities are situated on the site being used for growing the plant-breeding material. This centralization is of the greatest value in work of this kind. It has the virtue of every worker having his field-material continually under his day-to-day care, with the consequent efficient organization of time and labour. It is no longer a major expedition to visit material growing in the field, the laboratories do not suffer from isolation from the living material, while there is the easiest transition from field-investigations to laboratory work. The unification, and the ensurance of the integration of field- and laboratory-work, are essential for the proper organization of research work devoted to the study of the behaviour of cultivated plants in the field with special reference to their improvement.

The buildings comprise a main and an ancillary block, the former housing the offices, library, main laboratories and other services, and the latter including the implement sheds, soil sterilizing and potting rooms and glasshouses. The two blocks are served by a concrete road and are separated from one another by part of the experimental plots, being situated a quarter of a mile apart. All parts of the premises are consequently of easy access, and there is a minimum of transport of materials involved.

The main building has interesting features from the point of view of the organization of scientific research work devoted to a wide range of problems in a number of different plant species. In the first place, except for the facilities provided in the ancillary buildings, which are largely concerned with the glasshouse work, the whole of the working requirements are provided under the one roof. The building is of two stories, to comply with local planning requirements, although there is a basement laboratory under a portion of the south wing for housing controlled-climate chambers and refrigeration cabinets. The ground floor is, except for a conference and lecture room, devoted entirely to laboratories, a specially constructed fire-resistant seed store, a threshing room and a sugar-beet tare house: the whole layout having as its main objective the centralization of the main servicing departments in connexion with each crop section. This distribution has made it possible to devote the first floor primarily to private rooms, administrative offices and library, but there are also research laboratories for biochemistry, serology and cytology, and a large cereals room.

Although each crop section is provided with its own laboratory, it has been found necessary to provide in addition service laboratories such as cytology, chemistry, pathology and physiology for use by all sections, as well as the common facilities for controlled-climate growth, frost-hardiness testing, and germination tests. This means that there are essentially two kinds of laboratories—crop sectional and common service—to ensure adequate facilities for the different lines of investigation and the various crops included in the programme of the Institute. These developments are necessary to deal with the scientific techniques that must be incorporated in plant-breeding work involving the improvement of the important economic characters of crop plants.

Plant breeding is a slow process compared with some other branches of research work, and it can be very consuming in labour as well as time. Apart from the use of controlled-climate chambers for special purposes, and to increase the number of generations that can be handled in a given period of time, much can be done to economize in time and effort by the use of glasshouses, which are virtually essential for some aspects of plant breeding. The Institute is accordingly provided with standard heated glasshouses for the various crops, and it is possible thereby to continue certain investigations during the winter months. Special light-alloy glasshouses are being erected for the sugar beet programme, which is concerned particularly with the study of artificial polyploidy and other breeding techniques as well as the possibilities of developing beets resistant or tolerant to virus yellows disease. These glasshouses comprise two separate blocks; one is for studying breeding techniques and consists of four banks of air-conditioned compartments which can be used for controlled pollination and seed production of breeding material; the other block includes an insectary for raising aphids, an inoculation chamber, a fumigation chamber, and growing-on houses, the whole being designed to allow work on breeding for tolerance or resistance to virus yellows to continue throughout the year. Extra artificial illumination is provided for winter work, while the houses can be cooled in summer by blinds and water irrigation on the roofs.

The existing facilities provided at the Institute by these buildings and extra land are commensurate with the new responsibilities of the greatly expanded programme of research being undertaken. There is provision for expansion of the staff and of the work to cater for the requirements of plant breeding research on all the important arable crops of Britain.

OBITUARIES

Prof. R. W. Wood, For.Mem.R.S.

With the death on August 11 of Prof. R. W. Wood at the age of eighty-seven, science has lost one of the last links with the great experimental physicists of the past century. Though his principal contributions to science lay in the field of physical optics, Wood was a man of extraordinary versatility. An artist of no mean ability, a musician and, above all,

a teller of stories (not all suited to Victorian drawing-rooms), he had a keen sense of humour and an impish wit which made him the best of companions. Wood's "Physical Optics", now in its third edition, and his little satirical book of poems, illustrated by himself, "How to Tell the Birds from the Flowers", have both been best-sellers for many years.

Wood was a great traveller. Sabbatical years seemed to recur at very close intervals, and Wood's visits to Europe became almost an event in the scientific world. He never failed to bring with him something original and ingenious; and, of course, a fund of new stories. Like his great friend, C. V. Boys, Wood was essentially an experimenter who loved to do everything for himself. A craftsman in the laboratory arts and a manipulator of the very highest dexterity, Wood found it difficult to entrust any substantial part of his experimental work to others. When he embarked on an experiment, everything was sacrificed to its consummation in the shortest possible time. All apparatus and equipment, regardless of its normal purpose, was ruthlessly sacrificed to the end in view; and it only took some fifteen seconds to smash a perfectly good electric light bulb and extract the leadglass stem if Wood happened to be in a hurry for a bit of sealing-in glass.

Wood was born in Concord, Mass., in 1868, and was educated at Harvard and the University of Berlin. He became professor of experimental physics at Johns Hopkins University in 1901, where he took charge of Rowland's machines for ruling diffraction gratings and initiated the production of blazed echelette gratings for use in the infra-red. His published papers, which exceed 250 in number, cover a wide field and include experimental work in physical optics, on interference and diffraction and a study of the groove form and intensity distribution in gratings. He made extensive observations of the optical properties of the vapour of sodium at low pressure in which he observed the fluorescence and resonance spectra. Similar observations were made with the vapour of iodine. He studied the use of infra-red and ultra-violet photography of terrestrial objects and also their application to a study of the moon. These are only a few examples, chosen almost at random, of the many fields in physical optics in which he worked with such distinction. He was one of the really great experimenters with an almost uncanny flair for choosing the simplest and best method of attack. He seemed always to know what would work.

Wood received many honours, including Rumford Medals given by the American Academy of Arts and Sciences and the Royal Society, the Ives Medal and the Draper Medal of the U.S. National Academy of Science for his contributions to astrophysics. He was a foreign member of the Royal Society and was awarded honorary degrees by many of the leading universities of Europe. In 1892 he married Gertrude Ames, of San Francisco.

T. R. Merton

Lord Horder, G.C.V.O.

In his long life of eighty-four years, which came to an end on August 13, Lord Horder witnessed and participated in a revolutionary change in the science of medicine and in the organization of its service to the public. In any age he would have been successful, for he was endowed with that indefinable gift for recognition of disease, great skill in clinical examination and sympathy with human suffering which characterize the ideal physician. To these talents he added scientific knowledge and experience. Up to the present century the diagnostician's tools were limited to a few simple instruments to assist the otherwise unaided senses in the examination of the heart, lungs, eyes and larynx. Horder, trained as a pathologist, was able to add to the examination of the patient's body the examination of the patient's blood, his cerebrospinal fluid, his secretions and excretions. He was one of the first to bring the laboratory to the bedside, to foster and promote clinical pathology. It is little wonder that he soon became the most sought-after physician of his time.

Horder's early research work is recorded in contributions to the annual reports of the Medical Officer of the Local Government Board. In the report for 1906–7, he published a paper "On a Study of the Micro-organisms associated with Rheumatic Fever and Malignant Endocarditis". In the report for 1907–8 he contributed a paper with F. W. Andrewes "On the Behaviour of the Leucocytes in Relation to Infection by and Vaccination against the Pyogenic Cocci", and with M. H. Gordon reported "On an Investigation of Protective Agents in Meningococcus Infections". His chief contribution to clinical medicine was a paper on 150 cases of infective endocarditis in the *Quarterly Journal of Medicine* of April 1909, in which he stated that with care a positive blood-culture of one or other of three types of streptococci could be obtained in 90 per cent of cases. In 1907 he edited Abel's "Laboratory Handbook of Bacteriology"; he wrote on pleurisy in Allbutt and Rolleston's "System of Medicine" in 1909; and in 1910 he published his "Clinical Pathology in General Practice", in which he included an account of vaccine therapy. He edited the second edition of the "British Encyclopædia of Medical Practice", published in 1950, and in 1953 published "Fifty Years of Medicine", an expanded version of his Harben Lectures delivered at the Royal Institute of Public Health and Hygiene in December 1952, which are partly autobiographical.

Horder served on the Minister of Health's Advisory Committee during 1935–39, and during the Second World War rendered conspicuous service as chairman of a committee appointed to inquire into the health conditions of air-raid shelters, and also as medical adviser to Lord Woolton at the Ministry of Food.

He promoted many good causes. For example, physical medicine, industrial hygiene, eugenics, cremation and noise and smoke abatement owe much to his advocacy. In particular, the combating of two scourges of mankind, rheumatism and cancer, concerned him. He was chairman of the Empire Rheumatism Council from its inception in 1936 until 1953. As chairman of the Scientific Advisory Committee of the British Empire Cancer Campaign he rendered great service, and he largely instituted a clinical review and follow-up of all cancer cases in London hospitals. Only last year he attended an international cancer conference at São Paulo, Brazil.

"Those whom the gods love die young." Lord Horder gave a new interpretation of the aphorism, for up to the day of his death his mental powers were unabated, and he was still young in spirit, in enthusiasm, and in love for mankind and for the profession which he adorned.

Arthur MacNalty

NEWS and VIEWS

New President of the British Association : Sir Raymond Priestley

At the meeting of the General Committee of the British Association for the Advancement of Science held in Bristol on August 31, Sir Raymond Priestley was elected president of the Association in succession to Sir Robert Robinson. An appreciation of the scientific and educational work of Sir Raymond was published in *Nature* (169, 778 ; 1952) on the occasion of his resignation from the vice-chancellorship of the University of Birmingham.

Geology at the Imperial College, London : Prof. H. H. Read, F.R.S.

Prof. H. H. Read retires this year from the chair of geology in the Imperial College of Science and Technology, London, which he has occupied with signal distinction since 1939. After active service in the First World War, he returned to the Geological Survey of Great Britain to spend more than a decade in mapping the complex metamorphic and granitic rocks of the Highlands of Scotland and the Shetland Islands. From this wealth of field experience he drew inspiration for his much-quoted advocacy of the contaminated origin of norites, and for a series of classic contributions to geological literature entitled "Meditations on Granite" and "Commentaries on Plutonism". These and other philosophical writings have won him an international reputation as a leading exponent of metamorphic processes and metasomatic granitization, and election as foreign member of numerous geological societies throughout the world. For nearly twenty-five years he has been an enthusiastic and stimulating teacher, first at the University of Liverpool and later at the Imperial College, where he has built up a large and flourishing research school of geology. He was elected a Fellow of the Royal Society in 1939, and besides serving as president of the Geological Societies of Edinburgh, Liverpool and London and of the Geologists' Association, he was universally acclaimed as president of the International Geological Congress held in London in 1948. Four years later, the Geological Society of London awarded him its premier honour, the Wollaston Medal. Not content to rest on his laurels, Prof. Read is still actively engaged in studying the interplay between tectonics, metamorphism and plutonic phenomena in the Grampian Highlands, and in closely directing a team of research workers in a comprehensive investigation of the metamorphic, migmatitic and granitic rocks of Donegal in a concerted effort to illuminate the vexed problem of the origin of granites. Although he now relinquishes the chair of geology and the pro-rectorship of the Imperial College, it is gratifying to record that, as Senior Research Fellow, he will retain intimate ties with the department that thrived so much under his beneficent and invigorating guidance.

Oil Technology at the Imperial College, London: Prof. V. C. Illing, F.R.S.

Prof. V. C. Illing, professor of geology (oil technology) in the Imperial College of Science and Technology, London, retires at the end of the 1954–55 session. Prof. Illing is a graduate of Sidney Sussex College, Cambridge, and in 1913 went to the Imperial College to carry out research on the fauna of the Stockingford shales of the Cambrian. Early in 1914 he joined the staff of the Geology Department, and became associated with the newly formed Oil Technology Department, being appointed its first professor in 1936. In 1915 he first visited Trinidad, and so began a long association with oilfield operations in the Caribbean area. 1916 found him supervising work being carried out for the Aeronautical Inspection Department in a new laboratory in the Royal School of Mines. In 1944 he was awarded the Murchison Medal of the Geological Society, and in 1945 was elected a Fellow of the Royal Society. Prof. Illing is widely known for his research work and publications on oil migration and accumulation, and for the emphasis he has placed on the study of stratigraphy and geological history in assessing the oil possibilities of an area. He has also stressed the importance of selecting appropriate techniques in the search for oil fields. For many years he has been recognized as an authority on oil developments in Trinidad and Venezuela. His advice has also been sought on oilfield operations in many other parts of the world, and in 1947 he negotiated, on behalf of British and Dutch interests, a settlement with the Mexican Government in connexion with the expropriated oilfields.

Department of Scientific and Industrial Research : Mr. E. Barnard, C.B., C.B.E.

Mr. E. Barnard has recently retired from the post of deputy secretary in the Department of Scientific and Industrial Research. Mr. Barnard, who is sixty-three, had a distinguished career in the Gloucestershire Regiment during the First World War, being awarded the D.S.O., and then in 1919 he joined the Department of Scientific and Industrial Research as an assistant principal. In 1928 he was appointed assistant director of food investigation under Sir William Hardy, the then director, and in 1934 succeeded Sir William. He was director of food investigation until 1943, when he returned to the headquarters office of the Department as principal assistant secretary and deputy to the then head of the Department, Sir Edward Appleton. In 1945 the post of deputy secretary in the Department was created and Mr. Barnard appointed to it. He was made a C.B.E. in 1943 and C.B. in 1951.

National Coal Board Committee for Research into Human Problems

The National Coal Board has set up a Committee for Research into Human Problems, with the following terms of reference : "To consider and approve, in the form of programmes and budgets, the general lines of the Board's research on human problems, having special regard to the needs of Industrial Relations, Medical and Staff Departments ; to receive progress reports and to ensure that work on all the items in the approved programmes is properly and promptly carried out ; and that the results of research are adequately disseminated". Research into human problems will be carried out by the research branches of the Departments mentioned (and by outside bodies as well) and the Committee's function will be to supervise, with executive authority, the work of the various research branches. The Committee comprises Mr. J. Bowman (deputy chairman of the Board, in the chair), Sir Andrew Bryan (staff member), Mr. W. H. Sales (industrial relations member), Mr. A. H. A. Wynn (scientific member), Dr. W. Reid (production member) and

Mr. J. Latham (finance member). To provide the means of maintaining contact between all people engaged on this research and formal facilities for the exchange of ideas, an Advisory Committee will be set up, and its terms of reference will include the discussion of progress in research in the medical, human and management fields, the suggestion of the lines on which new research projects might be fruitfully developed, and consideration of the ways in which the information gathered and the research findings might most profitably be disseminated and used.

British Agricultural Delegation to visit the U.S.S.R.

At the invitation of the Government of the U.S.S.R. a British agricultural delegation is to visit that country; this invitation follows the recent visits to the United Kingdom of two agricultural delegations from the U.S.S.R. The United Kingdom delegation will be led by Mr. G. R. H. Nugent, Joint Parliamentary Secretary to the Ministry of Agriculture, Fisheries and Food. The delegation will leave for the U.S.S.R. on September 25 and will return on October 9; its programme will include visits to the Agricultural Exhibition in Moscow, to farms and to agricultural research and experimental stations. In addition to Mr. Nugent, the delegation will include: Prof. H. G. Sanders, chief scientific adviser (agriculture) to the Ministry of Agriculture, Fisheries and Food; Dr. E. E. Cheesman, scientific adviser, Agricultural Research Council; Dr. H. P. Donald, director of the Agricultural Research Council's Animal Breeding Research Organization, Edinburgh; Sir Peter Greenwell, member of the Council of the Royal Agricultural Society of England; Prof. D. S. Hendrie, principal of the West of Scotland Agricultural College; Dr. P. S. Hudson, director of Commonwealth Bureau of Plant Breeding and Genetics, Cambridge; J. Mackie, chairman of the Scottish Committee of the National Institute of Agricultural Engineering; Dr. A. Muir, head of Soil Survey of England and Wales and head of the Pedology Department, Rothamsted Experimental Station; Dr. J. A. B. Smith, director of the Hannah Dairy Research Institute; Dr. A. W. Stableforth, director of Veterinary Laboratories, Ministry of Agriculture, Fisheries and Food; W. C. Tame, under-secretary, Ministry of Agriculture, Fisheries and Food; and representatives of trade unions associated with agriculture. The *News Chronicle*, which was host for one of the recent Russian delegations to Great Britain during part of its stay, has also been invited by the U.S.S.R. to send six representatives; this group will travel with the official delegation, but will probably follow a separate programme.

The Cleanliness of the British Scene

As the result of a summer of outstanding brightness and delight, in which many in Britain have been prompted to spend the maximum practicable amount of time in the open air, the matter of dreary and blackened buildings, rendered more dismal by the onset of rain, may have been well forgotten for the time. The hour is fast approaching when the issues to be put before Parliament in the Clean Air Bill will arouse the Press, and the attention of the public will be directed to its hoped-for progress through the House. The summer issue, therefore, of a journal that has grown attractive from the efforts of those who have been zealous in the development of smoke abatement is of particular interest at the present time; it is *Smokeless Air* (25, No. 94), the official organ of the Smoke Abatement Society. With the smoke and air pollution that has been the result of the growth of industrial activity in the British Isles, there now looms before us the problem of radioactive pollution associated with the development of atomic energy so necessary to assist our survival as an industrial community. There is a timely reprint in this journal of an address by Sir John Cockcroft, given to the Parliamentary and Scientific Committee on the subject of radioactive pollution (see *Nature*, May 21, p. 873), which is for the time being reassuring. It yet defines a problem which has been very prominent in the news in recent months.

The same issue of *Smokeless Air* also contains a racy contribution from the pen of a Frenchman, Roger Valvert, entitled "A Frenchman looks at Britain's Smoke". A succession of pert reflexions on the Englishman's robustness and toughness in enduring his apparently barbaric forms of heating almost commends the scepticism with which the Beaver Committee report on "Air Pollution" was received last year. We read of "smog, that cocktail of smoke and fog, typical of London and other great industrial centres". Again, "Coal is scarce. One must not waste it. If then this method of heating does not heat, it teaches the English to live in what Continentals would consider cold". Another pleasant gibe runs, "The Englishman to our mind is badly fed and heated, but he has his own flat, or more often house, redecorated every two years, and a well-kept garden. He has a bathroom even if it is arctic. To teach him efficient heating is, therefore, to risk a catastrophe". The author fires his parting shot by suggesting that it would not be a bad thing to observe how the truly sporting spirit helps, that typical characteristic of the Englishman. We shall see when the battle is joined in the coming months. The editor of *Smokeless Air* deftly puts in a final *riposte* by observing that, according to a municipal councillor, the air of Paris will soon be as poisonous as that of London, and he quotes chapter and verse.

Colour in Foods

The Quartermaster Food and Container Institute in Chicago is an active centre for both fundamental and applied research in food technology. It is responsible for the specifications for foodstuffs supplied to the United States Army, and it maintains close relations with scientific workers in the universities, in industry and in other government departments. This co-operation is fostered through an Advisory Board established by the National Research Council and through various advisory committees, and during recent years a number of specialized conferences have been arranged jointly by the Institute and the Council. Several valuable reports of these meetings have already been published, the latest of these being on "Color in Foods", based on a symposium held in Chicago during November 3–4, 1953 (pp. 186; from the Quartermaster Food and Container Institute, 1819 West Pershing Road, Chicago 9, Ill.; 1954; n.p.). The sixteen contributors discuss a wide range of problems, including the fundamental concepts of colour measurement, the psychological approach to colour preferences, and the nature and reactions of the carotenoids and other food pigments. Several of the papers are concerned directly or indirectly with instrumentation, and they reveal the progress that has been made during recent years in the design of equipment both for research

and for routine tests on fruits and vegetables and their products. As a whole, much is included that is of interest to those who are concerned with quality control in food production; the symposium fully discussed the difficulties in correlating colour and quality—in particular, the necessity for considering separately each commodity in terms of its natural colour and of the changes during storage and processing, and also in terms of what is regarded as acceptable and desirable by the consumer. In this connexion, the symposium brings out not only differences in individual and community preferences, but also the effects of external factors such as modern restaurant lighting.

Archæological and Geological Investigations in South Australia

Australian investigators continue to advance our knowledge of the prehistory of their regions. Long ago it was suggested that little further progress could be made until sites yielding a definite stratigraphy of industries had been discovered and a correlation of cultures with the geological record determined; and further, that in this connexion the fauna associated with the various culture groups must be listed. The problems there are not at all easy to resolve. Prehistory continued until a recent date, and neither the later geology nor the palæontology has been as systematically studied as in Western Europe. A recent number of the *Records of the South Australian Museum* (11, No. 3; 1955) is a useful addition to our knowledge. It contains a long article on the late Tertiary marsupials of South Australia and continues with a study of certain archæological sites at Lake Menindee, a locality near the River Darling in western New South Wales. The Lake is almost always dry except in exceptionally wet periods, such as that, for example, of 1950. In the dune-like area near the northern end of the Lake a stratigraphical sequence of several cultures has been determined, namely, the Tartangan (at the base) and then the Pirrian, with the Mudukian on top. The remains of a fauna and some human bones have been recovered. The industries are made from material foreign to the district, and it would appear that we are dealing with hunting peoples who from time to time occupied the sites either when it was damp or during times of exceptionally heavy rainfall when the Lake had water in it. It would seem clear that at Menindee man was contemporary with extinct marsupials which he hunted for food, and that the dingo only arrived in New South Wales after the time of the first settlement. The age of the earliest levels could be the close of the Pleistocene or the very beginning of the Holocene. The account is well set out; but the illustrations are not adequate in the case of the stone implements. The drawing of stone tools is a specialized art, and more attention could well have been paid to it.

Scientific Research in India

In his Thomas Holland Memorial Lecture, given before the Royal Society of Arts on May 19, Sir Alfred Egerton spoke on "Scientific Research in India". After emphasizing that the fruitfulness of science is first and foremost not a matter of money but of outstanding men or women, Sir Alfred said that although much was started before India attained independence, including the Board of Scientific and Industrial Research and, later, the Council of Scientific and Industrial Research to administer the Industrial Research Fund, scientific research only obtained full recognition and encouragement after 1947. This Lecture was essentially an account of the national research laboratories and institutes of India, the work of which was reviewed by a committee with Sir Alfred Egerton as chairman. Sir Alfred thought that the creation of this chain of laboratories in so short a time and the organization it has involved are fine achievements which provide young Indian scientists with the means to show their mettle. He has faith in India's young scientists and technologists and believes that, with initiative and integrity, patience and persistence, they will do work in these institutes which will make them a worthy memorial to India's great public servant, the late Sir Shanti Bhatnagar.

Scientific Research at South African Universities

A third volume of the "Register of Current Scientific Research at South African Universities" has now been issued, covering research carried out in 1954 (pp. 262. Pretoria: Library and Information Division, Council for Scientific and Industrial Research, 1954). The entries are arranged alphabetically by university departments under their English names; but subject and description are given in the language in which the information was received: in future, it is proposed to supply an English translation of the subject where that is submitted in Afrikaans. There is no index; but a list of contents and a few cross-references afford reasonable safeguards against any particular research being overlooked, and even a comprehensive index could scarcely eliminate the need for a careful examination of the entries in any broad field.

Plant List of North-West Europe

Under the editorship of the Lund Botanical Society, comprehensive lists are being prepared of the plants of north-west Europe, including those of Sweden, Norway, Denmark, East Fennoscandia, Iceland and the Faeroes. In these lists, all species are given point values indicating their rareness within the area of the list, and their occurrence in the different countries is indicated by 'country signs'. Introduced species of diverse kinds are distinguished from the native ones by different types. The main list is completed by lists of synonyms (those most widely used are also given in the main list), of plants protected by law and registers. The present volume on vascular plants has been prepared by Nils Hylander (15 Swedish kroner). A similar list of mosses, algae and lichens (by H. Weimarck, T. Levring and H. Magnusson, respectively) was issued in 1936–37.

Audio-Frequency Power Measurements

The eighth in the series of "Notes on Applied Science" prepared by the National Physical Laboratory, Teddington, is a brief pamphlet dealing with "Audio-Frequency Power Measurements" (pp. 16. London: H.M.S.O., 1954; 1*s*. net). The concept of electrical power and its measurement is introduced by a theoretical consideration of a simple two-terminal load carrying a d.c. current and having negligible leakage between it and its surroundings; and the basic principles of power measurements in an a.c. system free of coupling are outlined before describing in detail the theory of operation of the three modern types of wattmeter. It is stated that on theoretical grounds the electrodynamic type of instrument is the least suitable for the higher audio-

frequencies. It is generally superior, however, to the electrostatic or thermal types for speed of response, constancy of calibration, temperature coefficient and other qualities, so that considerable effort has been made by designers to overcome its limitations at the higher frequencies, and the useful frequency-range may yet be extended above 10 kc./s. to 20 kc./s. Many useful practical details of the design and use of the instruments are interspersed with the theory, and the advantages and accuracy of the various types are indicated. Electrostatic and electromagnetic coupling effects are discussed briefly in one section, and the pamphlet concludes with a few remarks about three-phase power measurements.

Science Progress

THE latest number of *Science Progress* (**43**; July 1955) is once more a combination of interesting articles on various aspects of science, shorter descriptions of recent advances in astronomy, physics, meteorology, organic chemistry, geology and botany, some notes on researches and items of interest to scientific workers and the usual comprehensive and valuable list of book reviews. The articles include one on animal communication and the origin of human language by Prof. J. B. S. Haldane, statistical physics and its problems by Prof. C. Domb, aromatic halogenation by Prof. P. W. Robertson, and one by Dr. A. G. Lowndes on the use of the Wolf Rock phonolite as a means of tracing deepwater drift in the English Channel.

Recent Earthquakes

DURING May–July the greatest earthquake (magnitude 7¼) occurred on May 30 in the Volcano Islands (lat. 24½° N., long. 142½° E.), and seven other earthquakes caused damage. The most extensive damage was on July 20 at Cotacachi in Northern Ecuador; on July 16 moderate damage was done in the Ægean on Samos and at Soke in Turkey, where about five hundred houses were totally or partially wrecked, four people killed and twenty others injured. Minor damage was done on May 7 in California, May 11 in Ecuador, May 21 in Samoa, May 22 in Austria, and June 5 in Algeria. In Europe, earthquakes were felt in Switzerland (May 2 and 22, and June 16, 17 and 26), Germany (May 12, June 26 and July 2), France (May 12), Norway (June 3) and Spain (June 4). The epicentre of the German earth tremors was in the Onstmettingen–Pfeffingen–Tailfingen triangle, and they were felt with scale 5 (Modified Mercalli) on June 26 and scale 4 on July 2. The epicentre of the Norwegian earth tremor on June 3 was near Sognefjord. Aftershocks of the Orleansville (Algeria) earthquake have continued, and strong earthquakes have been numerous in the Aleutian Islands. On June 28 an earthquake occurred in the north polar region (lat. 86½° N., long. 70° E.) with magnitude 6. The greatest depth of focus during the three months was 700 km. for an earthquake on May 11 with epicentre at lat. 7° S., long. 123½° E., in the Banda Sea; and an earthquake with depth of focus 650 km. occurred on June 11 with epicentre at lat. 16½° S., long. 179° W., near the Fiji Islands.

Courses in Radiological Physics and Health Physics at the University of Chicago

THE University of Chicago has approved of two new courses leading to the M.S. degree in radiological physics or in health physics, both degrees being awarded by the Department of Radiology. The courses are full-time and last two years, the second of which is spent half on academic work and half in service in the Department at a nominal rate of pay. The work includes physiology, biochemistry, biophysics, anatomy, toxicology and radiological physics. Before they can be accepted, students must have completed the equivalent of the University of Chicago B.S. degree in physics. The courses will commence this autumn. Further information can be obtained from Prof. Lester S. Skaggs, Department of Radiology, University of Chicago, 950 East 59th Street, Chicago 37, Ill.

Biological Aspects of the Transmission of Disease

A SYMPOSIUM is being arranged by the Institute of Biology on "Biological Aspects of the Transmission of Disease", to be held at the London School of Hygiene and Tropical Medicine during September 29–October 1. Speakers will be drawn from all fields of biology concerned with disease transmission—bacteriology, virology, parasitology and plant pathology. The papers are being arranged in sessions, not by the organism transmitted, but by the method of transmission, that is, passive, direct, or indirect. In order that there can be a useful discussion, preprints will be available before the meeting for those intending to be present. Programmes for the symposium are available from the Institute of Biology, Tavistock House South, Tavistock Square, London, W.C.1.

Announcements

THE British Society of Rheology is holding a symposium on "Surface Rheology" at the Washington Singer Laboratories, University College, Exeter, during September 22–24. In the evening of September 23 the Society will hold its annual general meeting. Further information can be obtained from the honorary secretary, Dr. P. Feltham, The University, Leeds 2.

THE Industrial Section of the Royal Microscopical Society is organizing a symposium and exhibition under the title "Fibre Microscopy", to be held on November 16 at the rooms of the British Pharmaceutical Society, Bloomsbury Square, London, W.C.1. The papers and exhibits will include work with both the optical and electron microscope, and will be concerned with a large variety of fibres. Further information can be obtained from the Society at Tavistock House South, Tavistock Square, London, W.C.1.

THE eleventh British Commonwealth and Empire Lecture of the Royal Aeronautical Society will be given by Dr. J. J. Green at 6 p.m. on October 6 at the Royal Institution, 21 Albemarle Street, London, W.1. Dr. Green, who is the representative on the Canadian Joint Staff in Washington of the Canadian Defence Board, will speak on "The Growth of Aeronautical Research in Canada during the Post-War Decade". He was the first president of the Canadian Aeronautical Institute, founded in 1954. Further information can be obtained from the Secretary of the Society at 4 Hamilton Place, London, W.1.

WE regret that the obituary notice of Prof. G. F. Shirras in *Nature* of August 27, p. 376, was unsigned; it was written by Dr. John Murray, formerly principal of University College, Exeter.

THE WORLD HEALTH ORGANIZATION

VIEWED against the background of its basic functions and long-term objectives, the progress made by the World Health Organization in 1954 should be measured less by any particular achievement than by the development of a general attitude which, as a result of six years experience, most of its members seem to be taking towards it (Official Records of the World Health Organization, No. 59).

In all parts of the world there has been a better understanding of the real purposes pursued by the Organization. This evolution is clearly reflected by the nature of the assistance the World Health Organization is asked to provide: there is a definite trend away from requests for supplies and equipment towards requests for technical advice on virtually all aspects of public health. Authorities in many countries now realize that, to be truly effective, the resources of the World Health Organization should be utilized not so much for the temporary alleviation of their problems as for the strengthening of the permanent foundations of their health services.

The most encouraging aspect of the requests received by the Organization in 1954 is the desire shown by many countries to obtain help in working out long-term plans for the progressive and orderly development of their public health services. The growing attachment of Member States of the United Nations to the idea of international co-operation is demonstrated by the great number of inter-country and inter-regional projects. It is also reflected in the continued interest shown by countries in the Organization's efforts to co-ordinate on a regional basis activities carried out on a national level. These methods are being effectively applied in all areas and in practically all aspects of the Organization's work; during 1954, they were used in projects for the development of training facilities, for the exchange of scientific information, and also for the control of communicable diseases and their vectors.

A few examples will indicate the very important part such regional projects played in the total programme of the World Health Organization during 1954.

In the field of education, the Inter-American Centre of Biostatistics in Chile is making a valuable contribution to the improvement of vital and health statistics of all Latin American countries by training technical personnel for the various statistical services. The creation at Alexandria of a regional college of nursing is expected to go a long way towards raising the standards of nursing and nursing education in the countries of the eastern Mediterranean. Countries in Europe took advantage of the advanced training course for waterworks engineers, held in Belgium and the Netherlands, which was attended by engineers from eleven countries.

To exchange scientific information, an important seminar was organized in Wellington (New Zealand), at which thirty-seven participants, from twenty-one countries of the western Pacific, south-east Asia and eastern Mediterranean regions, discussed problems relating to dental health. The conference on African onchocerciasis, convened at Leopoldville and attended by some thirty experts from three regions, yielded valuable information for national and regional campaigns which are to be undertaken in Africa against that disease. The sanitary engineering seminar held in Venezuela proved most effective in promoting inter-American co-operation in the field of sanitation and in integrating public-health engineering activities into the general health programmes of the countries concerned.

An outstanding example of the role being taken by the Organization in the regional co-ordination of national campaigns against specific diseases is the combined effort to be made towards the eradication of malaria from the Americas as a whole. This campaign is to be based on the malaria-control work already being done by individual countries in that region, and on two inter-country programmes assisted by the Organization, one for the Caribbeans and one for Central America.

The second Asian malaria conference, attended by representatives from fifteen countries of south-east Asia and the western Pacific, which took place in the Philippines in November 1954, can be considered as a preliminary step in organizing an inter-regional campaign against this disease. The contacts arranged by the Regional Office for South-East Asia between health authorities of Thailand and of Indonesia are undoubtedly of help to the two countries in their great efforts to bring yaws under control.

There are many examples in the 1954 report of the part the Organization is playing in promoting and especially in co-ordinating essential research work going on in various countries. There is the testing of sorption of non-volatile insecticides by certain types of mud wall, carried out by seven institutes in the Americas, Asia and Europe, and co-ordinated by the Organization. There is also the programme started by the Organization to ensure collaboration among leading experts responsible for field epidemiology studies of trachoma and associated conjunctivitises in different areas of the world. A meeting organized by the Organization in Teheran brought together specialists from Iraq, Syria, Turkey and Iran for a useful exchange of information on the epidemiology of sylvatic plague. Arrangements were also initiated for the exchange of scientific workers between the Nutrition Research Unit in Kampala, the national laboratories of the Indian Council of Medical Research, and the Institute of Nutrition of Central America and Panama.

The overwhelming importance of environmental sanitation for the health programme of the great majority of Member States is emphasized in the report.

In addition to the advisory services in this field given during 1954 to a number of countries, preliminary studies were begun with the view of developing international standards for the quality of drinking-water on the basis of information received from about seventy countries. At the same time, the preparation of material relating to rural water supplies and excreta disposal continued, and it is hoped that this material will contribute to the improvement of sanitary conditions in the rural areas where more than three-quarters of the world's population live.

The scarcity of qualified personnel in the field of sanitation remains acute, and the highest priority is being given to the training of sanitary engineers and related personnel.

Training and education were at the very core of the efforts made by the Organization to assist countries to meet the many health needs of mothers and children, especially in rural areas. International teams, working side-by-side with national counterpart staff in twenty countries during the year, were principally engaged in training activities.

RESEARCH COUNCIL OF ALBERTA

REPORT FOR 1954

THE thirty-fifth annual report of the Research Council of Alberta* outlines the work of the Council for 1954, a year in which the geological research programme was enlarged to meet an increasing demand for basic geological information, and increased effort was placed on natural gas research. The construction of the Council's building was commenced; with its completion most of the scientific work will be consolidated under one roof, and more specialized testing and investigational work on behalf of industry will also be possible. The programme of more fundamental research on coal, initiated in 1953 with the object of advancing the knowledge of the constitution and behaviour of coal, was continued; an extended survey of the colloidal structure of typical Alberta coals by means of heat-of-wetting measurements was virtually completed and has confirmed the existence of a catenary type of relation between accessible inner surface and coal rank. More detailed measurements have been made of the sorption of oxygen by coal at − 25° to − 40° C. and considerable progress was made in studies of the effect of an ultrasonic field on the solubility of coal in such solvents as methyl alcohol. Laboratory studies of the low-temperature carbonization of Alberta coals indicate the possibility of modifying profoundly the course of carbonization by means of cracking catalysts, and studies have also been made on the following topics: the constitution of humic acids derived from coal and of the humic acid content of low-grade Alberta coals; techniques for concentrating spores from shales and various kinds of coal with the view of cataloguing plant microfossils of the uppermost Cretaceous and lowermost Tertiary formations of central Alberta; the suppression of surface dust on bituminous coal briquettes; the grindability of sub-bituminous coals.

In the work on petroleum, the study of trace metals (particularly vanadium, nickel and iron) in crude oils was extended to include oils from other oil horizons of the Western plains, and more recently to include magnesium, since the occurrence of magnesium in crude oils appears to be related to the presence of chlorophyll in the living material from which the crude oils are formed. Determinations of sulphur in these crude oils indicate no close relation between the sulphur content of a crude oil and its trace-metals content. A study of the settling characteristics of solid particles in emulsions of water in heavy oils showed that the presence of water retarded appreciably the settling characteristics of solid particles. Certain 'heavy oil' fractions appear to have special merit as a briquette binder and for preparing metallurgical coke, and attempts were also being made to separate the sulphur compounds present in 'heavy oils' from Athabasca oil-sands.

The research programme on natural gas has included the construction of a new furnace for studies on the formation of carbon black, and work on the partial oxidation of *n*-butane continued. A complete section of the McMurray oil-sands formation has been examined for oil saturation, grain-size distribution and heavy minerals analysis, and a Pleistocene research and survey programme initiated in the Coronation district. Mineralogical analyses of a number of clays from south-western and west-central Alberta were completed, and clay research was extended to include the Bearpaw formation.

The Council's part of the Alberta Soil Survey, a joint effort with the Dominion Experimental Farms Service and the University, included a reconnaissance survey of about eight hundred thousand acres, and an exploratory survey of four hundred thousand acres in the Grande Prairie and Beaverlodge areas. Despite exceptionally heavy rainfall, irrigation research in the Youngstown area showed beneficial effects from irrigation in relation to certain soil amendments and cultural practices, while the subsurface drilling operations initiated during the year are proving of value in soil surveys and irrigation research as well as in geological studies on clays and other non-metallic mineral deposits. Laboratory results in the Highway Research programme indicate that the chrome–lignin gel is as effective in reducing frost heaving as the plain lignosol, and may be more effective provided it is properly dispersed in the soil.

The Biological Cycles project shows that the ten-year cycle is now at what is assumed to be its complete ebb, with signs of recovery in places. In the Department of Animal Science at the University, the Council sponsored investigations of the factors affecting the percentage hatch of turkey eggs and of methods of improving the quality and yield of grass silage. Solar ultra-violet radiation measurements were continued, and an Advisory Committee on Industrial Pollution was constituted to provide technical guidance at an early stage in Alberta's industrial development in the hope of avoiding difficulties now encountered in older industrial regions. The committee appointed to study the fluoridation of public water supplies has now reported. At the end of the Council's report the usual list of publications is appended.

* Research Council of Alberta. Thirty-fifth Annual Report, 1954. (Report No. 69.) Pp. 47. (Edmonton: Research Council of Alberta, 1955.)

THEORY OF ADHESION

IT may be claimed that progress on the practical or empirical side of adhesion and adhesives is more rapid and even spectacular than on the theoretical; but, whether this is so or not, the fact remains that, in the field of production engineering and in other directions, rapid advance has been recorded, especially during the past year or two, some of the most remarkable results being achieved in aircraft design and manufacture. A detailed description of the purely practical application of adhesives to aircraft production is given by Mr. George Epstein, of the Aerophysics Department, North American Aviation, Inc., in his book, "The Adhesive Bonding of Metal" (New York: Reinhold, 1954), and, in lesser detail, in his contribution to the Basic Materials Conference, held in Chicago in May 1954[1].

Several contributions have recently been made to adhesion theory by workers in France, Germany and the U.S.S.R. By way of introduction to these, reference should perhaps be made to the interesting chapter by A. J. Staverman on molecular forces in relation to adhesion which is published in the book by de Bruyne and Houwink on "Adhesion and Adhesives" (1951). This chapter deals at some length with the molecular aspects, to which attention hitherto has been mainly directed, including different kinds of molecular forces and the significance of molecule size, polarity, etc., in connexion with both

cohesion and adhesion. It is rightly concluded that much yet remains to be done before we have a complete understanding of the nature of adhesion based on molecular characteristics.

J. Remond[2] includes a discussion of the problem of adhesion (*collage*) and endeavours to elucidate its scientific foundations. In his view, these are to be found entirely in the inter-atomic or inter-molecular forces which account for both the cohesion within matter itself and for its adhesion to another body. These forces have a common origin, are of an electrical kind, and are to-day divided into primary and secondary. It has been realized for some time that the electrical aspects, or in other words, molecular polarity, are of fundamental importance; but as will be seen later in this article when recent Russian ideas on the subject are considered, a new electrical conception of adhesion has been evolved. Meantime, the close similarity between cohesion and adhesion as indicated by Remond is of considerable interest. This has been stated elsewhere in another form: any adhesion theory which attempts to correlate thermodynamic factors, electrical charge factors, or molecular structure factors with the observed strength of an adhesive joint is, in effect, providing a theory of the strength of solids—cohesion—in terms of these factors. In this connexion, of course, one has to remember that the adhesive bond may sometimes be stronger than that of cohesion—for example, where the assembly breaks down, not at the adhesive joint but by fracture within one or other of the parts joined. One has to note, also, at least two kinds of adhesive fracture: where the adhesive film 'tears away' from one or both the joined surfaces, and where the film itself splits into separate laminæ.

Reverting to Remond's division into primary and secondary forces, the former play the leading part in the formation and existence of definite chemical compounds. They are distinguished from the secondary by "their greater importance" and property of saturation and of valency. The special case of carbon is briefly considered by Remond, in the formation of monomeric molecular chains. The secondary forces are those of the polymer, and obviously much weaker. He proceeds to consider some of the fundamental principles of adhesion, including artificial change of polarity, for example, by acid treatment, where this is necessary for effective adhesion, as in the case when rubber (non-polar) is to be joined to wood (polar). An interesting example is cited in the case of the manufacture of a heat exchanger by A. P. V. Co., Ltd.

A great deal of adhesion research is also proceeding in Germany, by such leading firms as Henkel and Cie., Huls, and the BASF (Badische Anilin u. Sodafab.) at Leverkusen. For the latter, Dr. H. Sonne is in charge of developments, and in reporting more particularly on work with dry (or pressure-sensitive) adhesives he has included some interesting notes on molecular structure in relation to adhesion[3]. Here again, cohesion and adhesion are both included in what presumably must be a wide interpretation of the German term *Klebfähigkeit*, or glutability. Undoubtedly, the old-fashioned term 'glue', which in the olden days meant practically only one kind of adhesive, as used by the village carpenter or handyman in his familiar glue-pot, is now applied to a vastly wider and more varied collection now that synthetic resins, and many other materials, have entered the adhesives field; but it is perhaps a little unusual to extend it so far as to include cohesion.

Dr. Sonne deals with high-molecular materials with side-valencies, in which a dispersion effect may be involved, or a disturbance, through chemical bonding, of the original natural frequency of the electron system; also, dipole effects of polar molecules may be involved (that is, an electrical moment). An accumulation of polar groups, as in long-chain molecules, must necessarily increase the total moment, and therefore also the outwardly acting forces. In the normal paraffin (CH_2) chain is a non-polar system of high symmetry but of low dispersion effect and relatively small outward force. But the introduction of side-groups or secondary chains causes immediately a non-symmetrical charge distribution which affects inductively the whole molecule; and this becomes more marked with increasing length of chain and number of side-groups, as in high-polymer compounds. Dr. Sonne draws the interesting distinction that "the dispersion forces of the main chain affect chiefly cohesion, while the dipole forces of the side-chains are chiefly related to adhesion". Thus, these side-chains act as innumerable 'fixing points' in the molecule.

In the manufacture of dry (pressure-sensitive) adhesives, compounds of such molecular structure are no doubt to be preferred—for example, those of the poly*iso*butylene (Oppanol *B*) and natural rubber type—as may be deduced from a consideration of their structural formulæ. Others that may be included in this category are the polyacrylates (COO*R*— side-groups), polyvinyl ethers (OCH_3—), polyvinyl chloride, polystyrol, Buna products, etc. All these materials have adhesive properties, actual or potential, but the relevant conditions and relations vary considerably, and are somewhat complex. Polymerizates of this kind almost invariably form isomeric mixtures, with chain structures of widely varying length and side-group. It is to be observed that the CH_3— side-groups are usually associated with high adhesive power, and it may reasonably be assumed that, with Buna rubbers for example, having lower adhesive powers than natural rubber, mixed polymerizates have been formed that should be of considerable interest in this connexion. Both the natural and synthetic rubber types, as regards the double bonds therein, have unique properties and failings. They are sensitive to the action of oxygen or light, with resulting changes that indicate a lack of stability prejudicial to adhesive power.

More recently, an important further contribution has been made in a symposium on the theory and practice of adhesion at a meeting of the American Chemical Society in Cincinnati (reviewed in *Chem. and Eng. News* of April 18, pp. 1639–40, under the heading, "Why does it stick?"). The symposium included papers on wettability in relation to adhesion, by W. A. Zisman (Naval Research Laboratory); an atomistic approach, by R. M. Gruver (Linden Laboratories), with a note on the electrical forces emanating from surface ions that are not completely surrounded by those of opposite charge; the failure of adhesive bonds involving passage over the free-energy barrier, and the significance of the absolute rate theory in connexion with adhesion, by Marshall R. Hatfield (3M–Minnesota Min. and Mfg. Co.); the measurement of adsorption tendencies in addition to physical test methods, by L. Reed Brantley (Occidental College); cementing various materials to glass, with particular reference to moisture resistance, by F. Moser (Pittsburgh Plate Glass Co.); epoxides and their superiority in this respect, by E. W. McGuiness (General Electric

Co.); new tool for study of structural bond breakdown, with special reference to metal/metal bonds, by S. M. Skinner (Case Institute of Technology); new apparatus for measuring adhesive bond strengths, provisionally called the 'hesiometer', by W. K. Asbeck (Carbide and Carbon Corporation).

An important contribution from the U.S.S.R. to the theory of adhesion, including claims for a new electrical theory, is to be found in a fairly long article by B. V. Deryagin[4], based on his own extensive research and that of other Soviet scientists. He observes that this subject, despite its wide and increasingly varied practical importance, has been neglected on the theoretical side. In the case of protective coatings and adhesive films, it used to be considered fairly obvious that the adhesive forces were of a molecular or chemical nature, in which the surfaces joined took part; but this did not appear consistent with actual measurements of the forces needed to tear away a film under conditions that did not greatly affect the strength of the film itself. These forces might be as much as 10^6 or even more ergs/cm.^{2}, according to the speed of tear, and this exceeds by many times that required for breaking chemical or molecular bonds. It is necessary here to consider also the number of molecules or chemical bonds per unit surface (one must note, too, many cases of apparent chemical bonding, as in that of rubber to steel by vulcanization).

As an aid to solution, the author thinks secondary phenomena often noted in film removal may be invoked, such as luminescence and crackling, that indicate electrical discharge. On this basis, the Soviet workers claim to have founded their new electrical theory, briefly as follows: on contact of any two bodies, conductors or not, as already known, two electrical layers form at the interface, positive and negative; with some difference of potentials through transfer of charge from one phase to the other, and expenditure of work against electrical forces in the interface, as in a condenser, this difference may be a fraction of a volt to several volts.

If tear-away is sufficiently rapid and does not involve also cohesion (integrity of film itself), there should be separation at identical points of the outer zones of both electrical layers. Differences of potentials between these will depend on distance of separation, and be limited by discharge possibilities. The author here discusses at some length variations in charge according to pressure of ambient gas (p), the validity of the laws of gaseous discharge—including Paschen's—and other factors including ionization. If the discharge gap (h) or potential (V) is known, the following formula gives the work expended (A): $A = 2\pi\sigma^2/h = \sigma V/2$, where σ is the charge density.

According to Deryagin, under the action of intensive forces of electrical attraction the electrons torn from one surface and dispersing with high energy impinge on the opposite surface, dislodging therefrom positively charged ions and also photons. There is movement towards the surface. Under the impact new secondary electrons are dislodged, and if the number of these exceeds that of the first the electrons multiply, leading to discharge. This may be further complicated in that impacts of positive ions may produce, together with electron emission, a secondary emission of negative ions and also a photo-effect. But the general mechanism and nature of the discharge are obviously not changed as a result of this. It is emphasized that, with a spark-over vacuum, the significance or value of the gap, but not that of the discharge potential, depends on the density of the charges of the double electrical layer.

In regard to the above formula, it has been shown that, choosing a definite value for density of electric charge, and using values of the potential V directly observable in the discharge tube under different gas pressures (including those in which discharge proceeds without participation of the gas itself), one can predict—in determining the work of removing the film (A) and in accord with experiment—how this value ought to change with changes in pressure and nature of ambient gas. Thus, by selecting the right value for density of charge of the double layer, agreement with experimental results can be obtained both under ordinary atmospheric conditions and under those of widely varying gas pressures. It is therefore claimed that the new theory, as regards agreement with experiment, has decisive advantages over the conventional theory that takes little account of gas pressures.

The new theory includes also an explanation of the experimentally found values of work done—up to 10^6 ergs/cm.^{2} or even more. In such cases, charge densities are obtained corresponding to a potential jump of not more than one volt; and this is only exceeded during the tear-away without discharge, when the voltage may be up to 10 kV. or more at discharge, according to charge density and pressure of ambient gas. Other evidence of the validity of the new electric theory is claimed by Deryagin to have been found in the observation and measurement of speed and energy of electrons emitted during tear-away of films in vacuum from metallic and non-metallic backing. He describes a method of observation, using a photographic film, an absorbent screen of thin foil or mica sheet for maximum speeds, and a magnetic field for determining deflexion. It was found, in agreement with theory, that intensity and energy of emission increased with speed of tear-away, and charges of 10 or more kV. are mentioned. They are of such magnitude that the work expenditure may be attributed mainly to overcoming these electrical forces.

Deryagin acknowledges, however, that this method of measuring electron speeds cannot be said to have a high degree of accuracy. Thus, without necessarily contradicting these measurements, it may be suggested that some part of the work, say 30–40 per cent, may be devoted to something else, such as deformation of the film during removal, with possible evolution of heat. But Deryagin is satisfied that these objections have little or no basic significance, and he produces lengthy arguments in support. He is quite certain that, compared with the electrical component, the molecular component is practically negligible.

It is easy to explain the effect of adsorption of dipole molecules on adhesion, as these form an oriented dipole molecular layer and may considerably modify the value of the potential jump. Some cases of such modification have been studied by A. N. Frumkin. Various considerations lead to the view that the effect is indirect, and may either increase or reduce adhesive power—as appears to be confirmed by experiment. Chemical interaction sometimes doubtless plays an important part, and the example of rubber-to-metal through vulcanization is again cited. But this by no means belittles or invalidates the new electrical theory. As already stated, the work expended on tear-off of film is usually much

greater than that needed to break the chemical bonds. Mechanical fracture of the diamond illustrates the absurdity of opposing chemical to mechanical and electrical factors. Reference is made to some Russian work on the electron theory of chemical affinity and of atom adsorption in crystal lattices. Similar reasoning may be applied in passing from surface adsorption to contact of a film with solid bodies, where the film contains mainly a polymer in solution—as is mostly the case with coating or adhesive films. The active atoms or groups in the film may enter into electronochemical union, accompanied by transfer of electrons from one phase to the other, obviously leading to formation of the double electric layer.

A possible objection to the new theory is to be found in the query: Why, in adhesive breakdown (delamification), is the double electric layer split up, though having in many cases the nature of a strong chemical bond, while there is little or no cohesive break along a line, probably of less or even of least resistance? Deryagin's reply is not very clear. He thinks that the principle or rule under which breakdown should occur along a line of least resistance is ambiguous and generally futile until a satisfactory measure of resistance is agreed. This line may vary, for example, with changes in speed of load application. If we consider splitting along a surface, in stages, and the measure of resistance is taken to be the specific work expended in tear-off, the principle of least resistance completely loses validity. This is discussed somewhat vaguely by Deryagin, and at length, including non-adhesive examples. In any event, it appears necessary to develop the theory somewhat further to permit combination of charge density in the double layer with the nature of functional groups in the adhesive, the presence there of active atoms and radicals, and the interaction between these structural elements of the adhesive and the surfaces to be joined.

Another approach to the problem of the origin of the electrical double layer, though possibly more limited, is to be found in studying the contact of a polymer film with metal. This is considered in connexion with electron transfer with the production of electron gas in the metal. In a vacuum such a transfer is only possible at high temperatures, such as those of thermo-emission or photo-effect. The formation and diffusion of the electron cloud and its results are also considered.

Referring to work in the United States by Skinner and colleagues[5], Deryagin considers that their theory of formation of an electrical double layer contains quite a few errors "and is probably only of qualitative interest"; Skinner *et. al* do not cite any of the Soviet work on this electrical theory of adhesion, and he claims that they have ignored the fundamental difference between simultaneous and gradual disturbance or fracture of contact over the whole area. There is no doubt, he continues, that the research already begun on the nature of film adhesion merits wider development, especially if this includes the really practical evaluation of adhesives in different fields of Soviet economy. It is very important to establish closer contact with workers in manufacturing industry directly engaged on new adhesive formulations and uses, and also those particularly interested in building up a sound scientific theory of adhesion.

Of special interest here is the so-called auto-conglomeration or self-adhesion (using terminology suggested by I. I. Zhukov) as observed in bringing into contact two identical strips of polymer, such as rubber. Experiment shows that the work of separating such double-folded strips increases not only with the speed of tear-off, but also with the duration of previous contact and amount of pressure. Such auto-adhesion, of course, is greatly affected by temperature conditions. All these various relations, including that between the structure of the polymer chains and their length, have been studied by different workers—for example, Voyutskii, Krotova, Deryagin and others—who have suggested that the phenomena of self-adhesion to a large extent are determined by intra-molecular thermal movement, forming the basis of polymer elasticity and leading, with contact of two polymer surfaces, to mutual interweaving and diffusion of their chains.

Thus, the surface of separation initially retained on bringing into contact two homogeneous polymers gradually disappears, and instead of two layers of polymer only one exists. Separation or tear now proceeds elsewhere, and the work involved is typical of the cohesion of the material. It is difficult to separate the macroscopic process, of gradual increase of true surface of contact of two materials, from the molecular mechanism of diffusion and interlocking of polymer chains. The initially true area of molecular contact will be considerably less than the apparently nominal. But gradually, owing to flow and relaxation of the polymer, the true area of contact will increase —with a tendency to approach the nominal. Since relaxation and plastic flow in polymers in turn are connected with deformation of macromolecular chains, it is difficult strictly to separate the two mechanisms—molecular coalescence and plastic flow in the contact zones. Further experimental research is necessary, including study of other fields of adhesion phenomena which, in the course of this review, cannot be considered here. W. G. Cass

[1] *Adhesives and Resins* (Jan. and March, 1955).
[2] *Rev. Produits Chim.*, **57**, 469 (1954); **58**, 70 (1955).
[3] *Kunststoffe*, **44** (9), 385 (1954).
[4] *Vestnik. Ac S.S.S.R.*, **7** (1954). Summarized also in *Research* (Feb., 1955).
[5] *J. App. Phys.* (May, 1953).

JOINT ESTABLISHMENT FOR NUCLEAR ENERGY RESEARCH

REPORT FOR 1953–54

THE third annual report of the Joint Establishment for Nuclear Energy Research, which has recently been issued*, contains details of the activities of the Establishment during the year ending June 30, 1954. The Establishment, which is located at Kjeller in Norway, is operated jointly by The Netherlands and Norway and is directed by Mr. Gunnar Rardars. The experimental equipment includes a 300-kW. heavy-water-moderated, natural-uranium reactor, Joint Establishment Experimental Pile (JEEP), which has been in continuous operation during the year, though four of the uranium rods were found to be defective and had to be replaced. An additional rod, bringing the total up to sixty-five, was required in order to compensate for the heavier load of isotopes. New equipment installed during the year included a pneumatic arrangement for removing isotopes quickly from the reactor and a mechanical

* Joint Establishment for Nuclear Energy Research. Third Annual Report, 1953–54. Pp. iii+28. (Kjeller, near Lillestrøm: Joint Establishment for Nuclear Energy Research, 1955.)

master-slave manipulator for remote handling of radioactive material.

The design of an experimental power reactor in which heavy water and natural uranium are to be used in a pressurized system has continued. The general planning has now reached an advanced stage, and recent work has been concentrated on the design of the natural-uranium fuel elements. The reactor is to be contained within a cylindrical pressurized stainless-steel tank, and the cooling circuit for the fuel elements, which is separated from the moderator, will provide hot heavy-water which will be used for steam production in a boiler connected to a conventional type of turbogenerator.

In November 1953 an extension to the building housing the pile was completed, and the physics, isotope and electronics laboratories and the offices for the Operations and Engineering Department are now housed together in this building. In June 1954 work was started on a new laboratory and workshop building to house the metallurgy and engineering groups and the Reactor Physics Department.

Work in the Chemistry Department has been divided between service tasks for other departments and the study on a laboratory scale of the chemistry of uranium and plutonium, particularly in order to design a pilot plant capable of dissolving up to ten tons of burned uranium rods a year, including the separation of plutonium and the reprocessing of the uranium metal. A 'hot' uranium slug was dissolved in concentrated nitric acid in an all-glass apparatus, the experiment being carried out by remote control behind a 40-cm. thick water wall. The solution obtained contained about 10 mgm. of plutonium. Arrangements have been made for the production of uranium metal by the reduction of uranium tetrafluoride with calcium. The uranium tetrafluoride was produced in accordance with the French method, that is, by reduction and fluorination of uranium tetraoxide, and the report states that uranium of a fair degree of purity has been obtained. Although the metallurgical laboratory is still under construction, some of the metallographic equipment has arrived, and studies of the de-gassing of uranium at elevated temperatures have been undertaken. The stabilization and canning of the uranium and the diffusion of uranium and aluminium at 200° C. and higher temperatures are other problems which have engaged the attention of the metallurgical group.

The production of isotopes has greatly increased, and the number of radioisotope shipments, namely, 335, is more than double that for 1952–53; 65 per cent of these shipments were for export. The different types of isotopes produced and the number of irradiations made in the several departments of the Establishment, together with the number of shipments, their destinations and main fields of application, are listed in the annual report. Stocks of radiocobalt and of radioiridium with fairly high specific activity suitable for industrial radiography have been developed, and many special isotope preparations of medical interest are, or will shortly become, available. No increase in the number of isotopes imported for distribution in Norway is reported. Eighty-four shipments were received from Great Britain, one from the United States and one from Canada. Three examples to illustrate the different technical applications of radioactive isotopes carried out by the Isotope Department during the year are described in some detail in the report. They are concerned with the transport of materials in rotary cement kilns, the loss of catalyst material in the industrial production of nitric acid, and the wear of ball bearings.

The sections of the report devoted to the activities of the Neutron Physics and Reactor Physics Departments are particularly interesting. The fission cross-section of uranium-235, the crystal structure of copper hydride and the magnetic structure of magnetite have been studied by the Neutron Physics Department. The principle of operation of the simple mechanical monochromator for neutrons used at the Establishment, the results of measurements of the rate of fission cross-section of uranium-235 and (n,α) cross-section of boron as a function of neutron energy, and the neutron diffractometer used for crystal structure analysis are some of the topics discussed in the report. The critical factors of various reactor designs were studied by the Reactor Physics Group; other problems considered were shielding properties of concrete, the effect of prompt and delayed γ-emission on the reactivity of the Pile and the rate of plutonium production in heavy-water reactors.

The report concludes with a list of the Establishment's reports and publications issued during the year, details of the staff of the various departments, and an abstract of the financial accounts for the period under review.

THE PHYSICAL SOCIETY

REPORT FOR 1954

THE report of the Council of the Physical Society for the year ending December 31, 1954, together with the report of the honorary treasurer and the annual accounts and balance sheet, were presented to the annual meeting of the Society held at the Royal Institution, London, on May 11, and adopted. Immediately following the annual meeting, Prof. H. S. W. Massey delivered his presidential address, entitled "Progress and Problems of Physics To-day", in which he described a selection of remarkable achievements in recent research in physics which illustrate the very advanced state of technique to-day, and then dealt with some of the problems, for example, the growing shortage of science teachers in schools and the tendency to extreme specialization, which the great expansion of research in physics has raised. The text of his address will be published in the separate issue of the *Proceedings* of the Society to be called the "Proceedings of the Physical Society Yearbook". The "Yearbook" will also contain the texts of the 1955 Guthrie Lecture and the Thomas Young Oration.

The report states that during the year the student membership of the Society decreased by approximately a quarter to 279, and the total membership fell to 2,046 with a net decrease of eighty-four. There was a small balance of income over expenditure; but the financial position at the end of 1954 was markedly less favourable than at the end of 1953, the deterioration being attributed, in particular, to a decrease in the income from the annual exhibition of scientific instruments and to the absence, in 1954, of a grant-in-aid in respect of the Society's publications. It is true that the cost of the Society's publications, including its commitment in respect of *Science Abstracts*, was almost balanced by the income from

sales; but the total cost of the Society's activities continues to rise and gives cause for considerable anxiety.

Five science meetings were held in London during 1954, including the summer meeting on July 7, 9 and 12, which was held in the Royal Institution in connexion with the General Assembly of the International Union of Pure and Applied Physics. Meetings outside London were held in University College, Dublin, during March 30–April 1, and in the University of Birmingham during December 13–14. In addition, a conference on the physics of the ionosphere was held in the Cavendish Laboratory, Cambridge, during September 6–9. The thirty-eighth Guthrie Lecture[1] was delivered by Sir Geoffrey Taylor, who spoke on diffusion and mass transport in tubes, and the seventh Rutherford Lecture by Prof. P. M. S. Blackett. Prof. A. Kastler, of the University of Paris, was the recipient of the ninth Holweck Medal of the Société Française de Physique and the Holweck Prize of the Physical Society; the presentation took place at the Royal Astronomical Society, Burlington House, on May 13, 1954, when Prof. Kastler delivered the Holweck discourse[2] entitled "Les méthodes optiques d'orientation atomique et leurs applications". The thirty-first Duddell Medal was presented to Prof. A. C. B. Lovell, who gave an address on the development and use of large radio telescopes, and the tenth Charles Vernon Boys Prize to Dr. J. S. Courtney-Pratt, who spoke on some new methods of fast photography.

At the request of a number of members, the Society reprinted the first five Rutherford Memorial Lectures, and the pamphlet, entitled "Rutherford, by Those who Knew Him", has been well received. Two special reports, "Defects in Crystalline Solids", representing the proceedings of a conference on this subject held in the University of Bristol during the meeting of the International Union of Pure and Applied Physics, and "The Physics of the Ionosphere", the proceedings of the Cambridge conference on this subject, have recently been issued. Vol. 17 of "Reports on Progress in Physics", containing eight reports, was published during 1954. A new departure was the issue, in addition to the bound volume, of each report as a separate booklet, with paper covers, to be purchased in any required quantity.

The thirty-eighth annual exhibition of scientific instruments and apparatus held at the Imperial College of Science and Technology, London, during April 8–13, 1954, had an attendance of approximately eighteen thousand and was again a great success. The four subject-groups of the Society—the Colour, Optical, Low Temperature, and Acoustics Groups—were all active during the year, and brief details of their membership and meetings are listed in the annual report. The summer meeting of the Low Temperature Group consisted of a visit, led by Dr. K. Mendelssohn and Dr. F. Din, to West Germany; on May 7 the party inspected the oxygen plant of the Messer Company at Hagen-Haspe, and during May 8–9, at Göttingen, a joint session was held with members of the German Physical Society at which scientific papers were read. A list of the numerous bodies and committees on which the Society is represented is also included in the report.

At the annual general meeting the officers and council of the Society for 1955–56 were elected as follows: *President*, Prof. H. S. W. Massey; *Vice-Presidents*, Dr. R. C. Evans, Dr. A. B. Wood, Prof. S. Devons and Prof. F. Llewellyn Jones; *Honorary Secretaries*, Dr. C. G. Wynne and Dr. H. H. Hopkins; *Honorary Foreign Secretary*, Prof. E. N. da C. Andrade; *Honorary Treasurer*, Mr. A. J. Philpot; *Honorary Librarian*, Dr. R. W. B. Pearse; *New Ordinary Members of Council*, Prof. W. E. Burcham, Prof. H. Jones and Mr. D. A. Wright.

[1] *Proc. Phys. Soc.*, B, **67**, 857 (1954).
[2] *Proc. Phys. Soc.*, A, **67**, 853 (1954).

NITROGEN NUTRITION, RESPIRATION AND AGEING IN *LEMNA* FRONDS

In a constant and favourable environment, each frond of *Lemna minor* has a finite length of life and a rate of ageing characteristic of the clone in its particular environment. Ageing, and the progressive diminution in frond-size which accompanies it, are not attributable to the production of daughter fronds, nor to a lack of auxin or adenine. Further, it has been found in surgical experiments that daughter frond area is determined by some substance in the mother frond (not auxin or adenine) which diminishes or is inactivated as the mother frond ages. E. Wangermann and H. J. Lacey (*New Phytol.*, **54**, 2, 182; 1955), in further investigations, have examined the relationship between nitrate nutrition, rate of respiration, and rate of ageing in *Lemna* with the following results.

Maximum length of life and minimum rate of ageing occurred at the lowest nitrogen-levels (less than 0·1 mgm./l.); minimum length of life and maximum rate of ageing occurred at intermediate nitrogen levels (about 0·25 mgm./l.). When rates of respiration of fronds at high and low nitrogen-levels were measured by the Warburg manometric technique, it was found that the rate of respiration of the low-nitrogen fronds (on an area or dry-weight basis) was below that of the high-nitrogen fronds throughout the whole of their life. There was no trend towards reduction in rate of respiration between maturity and death. The length of life was recorded of fronds the respiration of which was periodically inhibited by keeping them in an atmosphere of nitrogen during the dark period. Fronds thus treated lived considerably longer than those the respiration of which was not interfered with. From these results and those of previous experiments, it is tentatively suggested that a causal relationship may exist between rate of respiration and rate of ageing, slow respiration resulting in long life and *vice versa*.

A NEW FAMILY OF EARLY PRIMATES

The known primates and primate-like animals from the Palæocene and Eocene of North America and Europe are extraordinarily diverse. All are distinctly pre-anthropoid in structural grade and are considered in a general sense to be Prosimii or, in some cases, primate-like Insectivora. There has been a tendency to compare them either with the tarsiers or lemurs and to place them in the categories Tarsiiformes and Lemuriformes. Most of the supposed early Tarsiiformes have been classified

as Anaptomorphidae, and most of the supposed early Lemuriformes have been called Adapidae. A few other families, notably the Plesiadapidae, were also early recognized, although not well defined until more recently.

Over the years it has become evident that the early Cenozoic complex of primates and primate-like insectivores is far more complex than the usual classifications have recognized. It is also increasingly clear that the placing of many or, perhaps, any of them in the essentially Recent categories Tarsiiformes and Lemuriformes is arbitrary and is not a clear expression of their real affinities. A more recent tendency has been to pick out from the mass smaller groups of genera and species which are related among themselves, whatever may be their relationships to their contemporaries or to Recent prosimians, with which most of them seem to have no special relationships.

Phenacolemur, a member of this early complex known since 1915 when it was named by Matthew, is a highly distinctive, primate-like animal. It was at first confused with the distinctly different Plesiadapidae and Apatemyidae and recently has been considered simply as a primate, or perhaps insectivore, *incertae sedis*. Knowledge of the genus has increased, and there are now numerous specimens in collections from the late Palæocene and early Eocene Mountain region. Among recent discoveries is a specimen with associated upper and lower jaws and a skull. George Gaylord Simpson now gives a much fuller account of the genus than any in the scattered literature and considers its affinities on a far better basis (*Bull. Amer. Mus. Nat. Hist.*, **105**; 1955). A fairly well-defined group, designated as the Phenacolermuridae, emerges as a further contribution to the clarification of the heterogeneous mass of early Cenozoic primate-like mammals.

STRUCTURE OF POLY-L-PROLINE

By PAULINE M. COWAN and STEWART McGAVIN
Wheatstone Physics Laboratory, King's College, London, W.C.2

THE configuration of the peptide linkage which involves proline nitrogen is at present unknown. A knowledge of its configuration has an important bearing on the determination of the structure of proteins containing proline, especially that of collagen. Collagen not only contains a high proportion of proline and hydroxyproline, but also recent evidence[1] (and unpublished work by Kroner, Tabroff and McGarr) suggests that the sequence (pro, hypro) occurs as a significant fraction of the total.

Poly-L-proline has recently been synthesized by Berger, Kurtz and Katchalski[2]. They have very kindly supplied us with a sample having an average degree of polymerization of $n = 20$ which had been obtained by polymerization in dioxane. We have examined this material by X-ray diffraction.

The untreated material gave an X-ray powder pattern, all reflexions of which could be indexed on a hexagonal lattice with $a = 6{\cdot}62$ A. and $c = 9{\cdot}36$ A. No reflexions were observed at positions corresponding to indices 0001, 0002, 0004, 0005; but there were no other systematic absences. This indicates a three-fold screw axis parallel to c.

These deductions were confirmed by photographs of oriented films obtained from solution in *m*-cresol. The X-ray diffraction patterns first obtained from these films indicated a more complex lattice in which solvent was clearly incorporated. In the course of time, solvent was lost and a fibre diagram was obtained in which the reflexions had spacings the same as those of the original sample (Fig. 1). In the oriented films the c-axis was parallel to the direction of shear. Poorly oriented fibres were also obtained in which the c-axis was perpendicular to the fibre axis. Photographs of the original powder dispersed from alcohol were taken by Mr. R. E. Burge of this laboratory by means of electron diffraction, and show reflexions on a hexagonal net giving $a = 6{\cdot}57$ A.

The density of the original material was found by flotation in benzene/carbon tetrachloride mixtures to be 1·32 gm.cm.$^{-3}$. This is in reasonable agreement with the value, 1·36 gm.cm.$^{-3}$, calculated for three proline residues in the unit cell. The structure must therefore consist of polypeptide chains situated at trigonal positions, each having three equivalent residues related by an exact threefold screw axis, the 'residue repeat' along the c-axis being 3·12 A. These conclusions, and the lack of symmetry in the amide group, limit the space group either to $P3_1$ or $P3_2$.

In crystal structures of simple peptides, the amide group normally has a planar *trans* configuration[3]. It seemed reasonable to suppose that this configuration would also occur in poly-L-proline; but, in view of the unique character of the residue, models were also constructed with planar *cis* groups and

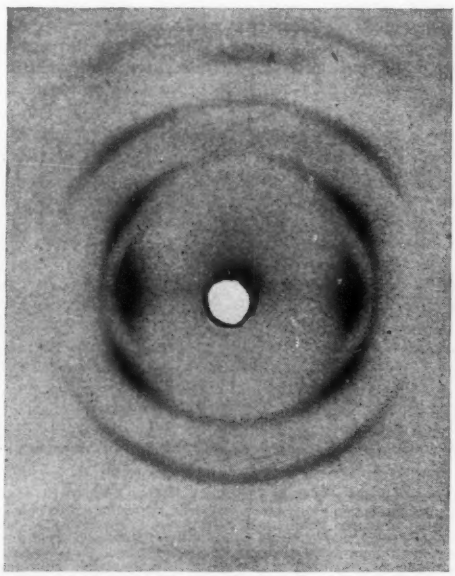

Fig. 1. X-ray diffraction photograph of poly-L-proline sheet oriented from *m*-cresol, slightly tilted, X-ray beam parallel to sheet

with pyramidal nitrogen. The proline ring[4] is puckered, with the γ-carbon atom of the 'side chain' about 0·5 A. from the plane of the other atoms in the ring. Such a ring can readily be attached to an amide group without great distortion of valency angles. In preliminary model building, the ring may be assumed to be planar.

In *cis* amide groups the distance between α-carbon atoms is expected[5] to be about 2·83 A. Considerable distortion of bond angles is necessary for the construction of a chain with repeat of 3·12 A., if composed only of *cis* residues, and such a structure is considered improbable. A model of the required dimensions can be built using pyramidal nitrogen. It seems likely, however, that the proline ring would tend to stabilize a planar form of the amide group. The reported value[2] of the C=O stretching frequency of 1,640 cm.$^{-1}$ tends to confirm this view (the low value being associated with considerable resonance in the amide group). Attention was turned chiefly to the construction of models consisting of the planar *trans* form.

Using, in the first instance, a completely planar residue, with dimensions close to the normal values[3], it was shown that a three-fold helix with repeat 3·12 A. could be constructed if some distortion is allowed at the α-carbon atom. The actual angles depend on the tilt of the plane about the line joining α-carbon atoms. Two models were considered: (1) with C_2—αC_1—N_1 and C_2—αC_1—βC_1 respectively 116° and 103° (both as near tetrahedral as possible); (2) with C_2—αC_1—N_1 and C_2—αC_1—βC_1 109° and 97° respectively. Both forms are strained. In addition, (1) has two short contacts, O_2 to N_1, 2·90 A. and O_2 to βC_1, 2·86 A. In (2) the strain can be relieved by removing βC_1 from the plane of the ring by 0·4 A., when C_2—βC_1 becomes 111°. This arrangement is illustrated in Fig. 2, and co-ordinates for the atoms of a single residue are given in Table 1. In this model, all contacts between non-bonded atoms are normal, with the exception of O_2 to N_1, 2·72 A. No hydrogen bonding is possible, but substitution on the nitrogen might be expected to increase the polarity of the amide group, since the increased polarizability of the substituted nitrogen facilitates further transfer of negative charge to the oxygen. Attraction between $O_2^{\delta-}$ and $N_1^{\delta+}$ might be expected to favour a *cis* arrangement of the C_2—O_2 and αC_1—N_1 bonds, but this is prevented by steric hindrance between $O_2^{\delta-}$ and $O_1^{\delta-}$. The position adopted in the model corresponds to a rotation of nearly 30° from this orientation (that is, close to the alternative configuration suggested by Pauling and Corey, but considered by them to be less favourable, ref. 5, p. 731). It is very similar to that of the carbonyl C—O with respect to the C—$\overset{+}{N}$ (H_3) bond in β-glycyl glycine[6] and unlike that preferred by the carboxyl C—O, which is very nearly coplanar with the adjacent C—N in this and almost all other peptides and amino-acids.

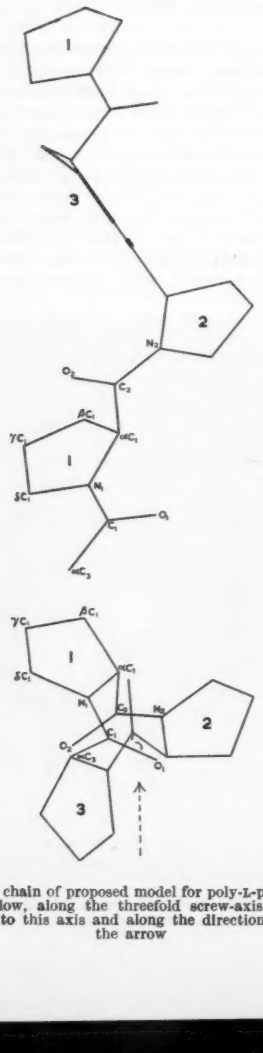

Fig. 2. Single chain of proposed model for poly-L-proline, seen in projection, below, along the threefold screw-axis, and, above, perpendicular to this axis and along the direction indicated by the arrow

Table 1. Polar Co-ordinates for a Single Residue of the Proposed Model for Poly-L-Proline

Atom	r	φ	z
αC_2	1·30 A.	0° 00′	0·00 A.
C_1	0·32	− 12° 30′	1·14
O_1	1·14	− 109° 30′	1·28
N_1	1·01	76° 00′	1·95
αC_1	1·30	120° 00′	3·12
βC_1	2·68	103° 30′	3·44
γC_1	3·17	77° 00′	2·86
δC_1	2·44	63° 00′	1·75

It is of interest to note that the helix described is left-handed if the absolute configuration of the α-carbon atom is assumed[7]. A right-handed helix of the required dimensions cannot be built with L-residues. The space group is therefore $P3_1$.

The positions of the three-fold axes of the chains are fixed by symmetry. The actual positions of the atoms with respect to the unit cell axes are not fixed, and these will be determined largely by van der Waals interactions between atoms in adjacent chains. For the above model two packing positions appear to be possible, one of which gives better agreement between observed and calculated intensities than the other. This arrangement, however, includes regions of rather low density. A somewhat more even distribution may be achieved by changes in the exact configuration. In the absence of hydrogen bonding, some rotation may be allowed about the C—N bond, as in N,N′-diglycyl cystine[8]. Both γ- and β-carbon atoms may be in a plane other than that of the amide nitrogen. Refinements along these lines are proceeding, together with an attempt to obtain better data with which to test the model. Details will be published elsewhere.

A perpendicular dichroism for the infra-red C=O stretching frequency has been observed in oriented films by Mr. G. R. Wilkinson of this laboratory, to whom we are indebted, and this is in agreement with our model.

From steric considerations the helical configuration is likely to be rather closely maintained in solution, which may account for the high specific lævo-rotation[2]. Again, in collagen, the polypeptide chains may have a similar, although less tightly coiled, configuration. This will be discussed elsewhere.

We thank Prof. E. Katchalski and his co-workers of the Weizmann Institute, Rehovoth, Israel, for making several samples of the polymer available to us and for their comments on our work. We are also grateful to Prof. J. T. Randall for his continued advice and encouragement throughout the course of this work. We should like to acknowledge the helpful discussions we have had with our colleagues of this laboratory, and with Mrs. D. M. Hodgkin of the Chemical Crystallography Laboratory, Oxford. We are both indebted to the Nuffield Foundation for the award of research fellowships, during the tenure of which this work has been carried out. [May 17

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CHANGES IN ANIMAL TISSUE AFTER HYDROCORTISONE ADMINISTRATION

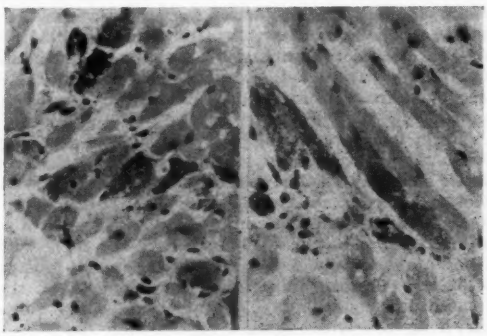
Production of Dystrophic Calcification of Cardiac Muscle in Mice by Hydrocortisone

IN the course of studies on the growth of a transplantable mammary carcinoma in mice as influenced by the administration of adrenal and pituitary hormones, we made the unexpected observation that dystrophic calcification is produced in the myocardium of animals treated with hydrocortisone. So far as we are aware, this type of lesion has not previously been noted as a result of hydrocortisone therapy.

Fifty-four virgin female mice of the C_3H strain, 2–3 months old, were inoculated by trochar with fragments of a transplantable mammary adenocarcinoma in the subcutaneous tissue of the back. Seven days later the animals were apportioned into two groups. One group (twenty-five mice) served as a control, and the remaining animals were injected with hydrocortisone acetate (Merck) according to the following regimen of daily doses: 0·2 mgm. for fourteen days, followed by 1·0 mgm. for twenty-one days, with a final dose of 0·5 mgm. until the end of the experiment. Both groups received a daily dose of 1·0 mgm. of terramycin in addition to the hormone; all injections were administered subcutaneously. The average survival-times of the experimental and control groups were 40 (28–78) and 52 (24–77) days respectively. At the end of the experiment, the average weight of the tumours in the group injected with hydrocortisone was only 0·5 gm., while that of the controls was 13·3 gm. at death. These data confirm the previous observations[1] that hydrocortisone inhibits the growth of transplantable tumours, in addition to shortening the survival-time of the tumour-bearing animals.

Calcific deposits were grossly visible in the heart tissue of those mice which survived treatment with the adrenal hormone for thirty days. The extent of deposition was roughly proportional to the length of survival and hence to the duration of the injection period. Microscopically the hearts showed extensive calcification and degeneration of the muscle fibres (Fig. 1). The nuclei manifested occasional variability with respect to size and shape, some being small and pycnotic. There were granular, basophilic deposits of variable size spread throughout the myocardium of the right and left ventricle and the interventricular septum. The smallest deposits were located within muscle fibres, and were found to stain typically with the alizarin red stain for calcium. In contrast, no such lesions were seen in the myocardium of any animal in the control group.

Additional studies in tumour-bearing C_3H mice have shown that similar myocardial degeneration associated with the deposition of calcium can be produced by high doses of adrenocorticotrophic hormone. Concomitant injections of growth hormone, with either hydrocortisone or adrenocorticotrophic hormone, seemed to potentiate these changes, whereas prolactin prevented their appearance. Non-tumour-bearing female C_3H mice treated for ten days with hydrocortisone and autopsied forty-five days later also manifested similar degenerative changes. In



(*A*) (*B*)

Fig. 1. (*A*), cross-section of cardiac muscle of a tumour-bearing mouse treated with hydrocortisone acetate for a period of 35 days. The various stages of calcification of the fibres should be noted: the earliest stages are represented by granular basophilic material in the fibres and the later stages by more extensive areas of calcium deposition. (Hæmatoxylin and eosin, × 280.) (*B*), longitudinal section of cardiac muscle of a tumour-bearing mouse treated with hydrocortisone acetate for a period of 35 days. Calcification of the muscle fibres and the slight mononuclear cell response should be noted. (Hæmatoxylin and eosin, × 280)

another study[2], where analogous observations were made in normal animals treated with hydrocortisone, biochemical investigation of the heart tissue confirmed the histological observation that deposition of calcium is associated with these lesions.

These incidental findings obtained with a potent hormonal agent emphasize that, when one has recourse to a hormone for one specific therapeutic effect, it is essential to bear in mind the tremendously far-reaching effects that may be exercised by that hormone on all tissues of the body.

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Lowell L. Sparks
Werner Rosenau
Rex N. MacAlpin
Thomas A. Daane
Choh Hao Li

Hormone Research Laboratory and
the Department of Anatomy,
University of California,
Berkeley, California.

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Deposition induced by Hydrocortisone of Calcium in the Heart Tissue of Female C_3H Mice

It is reported in the previous communication that chronic administration of hydrocortisone acetate to tumour-bearing C_3H mice in high dosages produces degeneration of the cardiac muscle fibres. Histological examination of the heart tissue revealed deposition of a mineral material which stains positively with an alizarin dye, suggesting the presence of calcium. These observations have now been confirmed in acute experiments with normal female mice of the C_3H, Heston *A* and *B*-albino-*C* strains. Progressively higher values for the calcium content of the heart tissue, as determined by the spectrophotometric method, were noted in hydrocortisone-treated animals as the hormonal dosages were increased, paralleling the degree of mineral deposition observed grossly. These findings invite interesting speculation with regard to the similarity between what is noted here and the pathological changes seen in certain clinical conditions[1,2], although extreme caution must be employed in translating data from one species to another.

Virgin female mice (fifty days of age) of the C_3H strain were given daily subcutaneous injections of either saline or a saline suspension of hydrocortisone acetate (Merck), in a daily dose of 0·25–2·5 mgm. As a prophylactic measure, all animals were also injected intraperitoneally on the first two days with 1 mgm. of terramycin in 1 ml. of a 5 per cent glucose solution; despite this precaution, several of the treated mice succumbed to infection. Only those surviving the entire period of injection have been included in the final analysis.

On the day following the tenth injection, the animals were anæsthetized with nembutal; the heart, adrenals and thymus were removed and weighed. For the calcium determinations, the heart tissue from four or five animals was pooled in a porcelain crucible and ashed in a muffle furnace at 900° F. The ash was taken up in concentrated hydrochloric acid and the calcium was precipitated as the oxalate[3] at approximately *p*H 4. Following centrifugation, the precipitate was thoroughly washed with 2 per cent ammonium hydroxide, dissolved in 1 *N* hydrochloric acid and made up to a 5 ml. volume with distilled water. The calcium content was then estimated in a flame spectrophotometer at 554 mμ with appropriate standard solutions[4].

Results are summarized in Table 1. As was to be expected, hydrocortisone caused thymic involution and adrenal atrophy; in addition, the hormone produced hypertrophy of the heart tissue. The spectrophotometric analysis of the myocardium afforded both identification of the mineral deposition as a calcium salt, and a means for quantitative estimation of the calcium content, which was shown to be a function of the hormonal dosage. While only small increases were obtained with 0·25 mgm. of the hormone, a ten-fold increase was evident at a dose-level of 1·0 mgm. The microgram quantities listed in the table for calcium should not be thought of in absolute terms, since some variation was found from week to week between appropriate groups given a standard amount of hydrocortisone for the 10-day period. Nevertheless, the comparative increases of calcium observable in the groups receiving progressively higher hormonal dosages were remarkably constant.

Table 1. The Effect of Hydrocortisone Acetate on Organ Weights and Calcium Deposition in C_3H Mice

Daily dosage (mgm.)	No. of mice	Body weight at autopsy (gm.)	Adrenal weight (mgm.)	Thymus weight (mgm.)	Heart	
					Weight (mgm.)	Calcium content (μgm./100 mgm.)
0	10	19·5	4·0±0·1*	41±2·4	92±3·6	2·2
0·25	7	17·0	3·0±0·03	nil	124±9·1	6·4
0·50	10	18·5	2·9±0·06	nil	124±3·9	17·2
1·0	5	18·0	3·1±0·1	nil		25·3
2·5	5	17·0	2·8±0·4	nil		27·9

* Mean ± S.E.

No conclusion can be drawn from the present results with regard to the amount of circulating steroid necessary to induce the observed pathological changes. When the hormone is administered subcutaneously as a saline suspension, considerable quantities of unabsorbed material accumulate beneath the skin. Moreover, doubling the dosage offers no assurance that the total absorption is increased proportionately.

Irrespective of these recognized variables in absorption, these results indicate clearly that the hydrocortisone administered is responsible for the relatively constant occurrence of calcific depositions in the right ventricle of the heart and for their incidental appearance in the liver and other viscera. The mechanism of its action and the influence of other endocrine factors remain to be investigated.

We wish to thank the Albert and Mary Lasker Foundation for research grants which have aided greatly in this investigation.

Ardis Lostroh
Choh Hao Li

Hormone Research Laboratory,
University of California,
Berkeley, California.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Palæomagnetism of Sediments from the Colorado Plateau

On the Colorado Plateau of Arizona and Utah there are exposed, as a result of erosion, sedimentary strata substantially undisturbed since deposition, representing almost every period of geological time. In the Grand Canyon of the Colorado River, for example, there are sediments ranging in age from the late Pre-Cambrian or Algonkian to the Permian, and in Zion Canyon and the Painted Desert Mesozoic sediments are found. Thus this part of the south-western United States is ideal for palæomagnetic work, and I had long wished to make a collection of rocks there for this purpose.

A further advantage of this group of rocks is that throughout the geological column fine-grained red sandstones frequently occur. Experience in palæomagnetic measurements in Great Britain[1] has demonstrated that these sediments are particularly suitable for this work. In any one formation the directions of magnetization of different specimens are reasonably closely grouped together; presumably because quiet conditions during deposition enabled the magnetized iron oxide mineral grains to set with their magnetizations parallel to the geomagnetic field at that time. The magnetizations of such red sandstones can often be shown by certain field-evidence to have remained unchanged in direction, relative to the rock, since deposition; presumably because the high coercive force of the hæmatite, usually the chief ferromagnetic mineral, gives the rock a high magnetic stability.

Last summer, thanks to grants from the Geological Society of America and the Museum of Northern Arizona, I was able to carry out the necessary field-work, the remanent magnetization of the samples obtained being measured early this year with the Cambridge astatic magnetometer. Measurements of the palæomagnetic directions in Tertiary times[2] (1–60 million years ago) had shown that the mean geomagnetic field in this period is very closely that of a geocentric axial dipole along the earth's present axis of rotation. Similar measurements in Great Britain[3] on pre-Tertiary sediments and igneous rocks had shown that the mean palæomagnetic direction changes slowly through geological time, but not appreciably in any one period (about fifty million years on the average). These results have been interpreted[3] in terms of a slow migration of the axis of rotation through the earth carrying with it the mean axis of the geomagnetic field. This is quite a different phenomenon from that of reversals of the magnetization of rocks, which are geologically rapid phenomena and are inferred to be due to reversals in polarity of the geomagnetic field, which regains its axial character when the reversal is completed. The measurements of the Arizona strata provide the opportunity for a test of the polar-wandering hypothesis, and the results are here summarized.

Table 1 compares the positions of the north pole from United States formations of five different periods with the positions calculated from the European formations of the same or similar geological age. These positions are normally computed from the mean direction of magnetization of a number of samples well separated stratigraphically. But in one formation (the Springdale sandstone) the palæomagnetic direction taken is not that of the mean but one which allows approximately for the appreciable magnetic instability of these sandstones, which biases their mean direction towards that of the present geomagnetic field. In the other cases a curve may be described around the pole position which, to a probability of 95 per cent, will contain the true position of the pole for that period. The two semi-axes of this curve are listed in brackets below the respective pole positions in Table 1.

The motion of the pole as deduced from the measurements of British strata consists of a gradual movement from near Hawaii in late Pre-Cambrian times towards the Pacific coast of Asia in Palæozoic times, reaching a high latitude in Triassic times and substantially the present pole position in Cretaceous times. The measurements on the Arizona strata give a similar picture. As is seen from the Devonian pole position given in Table 1, it seems possible that the motion of the pole was not smooth: in fact, it may have been rather like a random walk. It is thus impossible to tell at this stage whether the discrepancies between the pole positions inferred from 'contemporaneous' strata in Great Britain and Arizona are due to systematic errors or to the strata not being truly contemporaneous. The most serious discrepancy is that of the Permian strata; but the British measurements are at present restricted to a

Table 1. Comparison of Pole Positions deduced from Palæomagnetic Measurements in Europe and Arizona

Era	Period and age	Europe		Colorado Plateau	
		Formation	Position of N. Pole	Formation	Position of N. Pole
Tertiary	Miocene (20 million yr.)	Icelandic basalts (J. Hospers's data)	81° N. 171° E. (18°, 16°)		
Mesozoic	Cretaceous (80 million yr.)			Dakota sandstone	76° N. 127° E. (11°, 9°)
	Triassic (150 million yr.)	Keuper marl (Clegg, Almond and Stubbs's data, ref. 4)	47° N. 122° E. (13°, 7°)	Springdale sandstone (Zion Canyon)	60° N. 110° E.
	Permian (200 million yr.)	Exeter traps (K. M. Creer's data)	49° N. 162° E.	Supai shales (Grand Canyon)	23° N. 119° E. (8°, 6°)
Palæozoic	Carboniferous (250 million yr.)	Sandstones and siltstones in Derbyshire (J. C. Belshe's data)	36° N. 137° E.	Naco sandstones	49° N, 120° E. (4°, 4°)
	Devonian (300 million yr.)	Old Red Sandstone (K. M. Creer's data)	34° N. 156° E. (10°, 5°)		
Pre-Cambrian	Late Pre-Cambrian (about 600 million yr.)	Torridonian (E. Irving's data)	5° S. 131° W. (8°, 5°)	Hakatai shale (Grand Canyon)	30° N. 148° W. (10°, 9°)
		Longmyndian (K.M. Creer's data)	2° N. 118° W. (13°, 7°)		

few lavas which may not span a sufficient time to eliminate the effects of the geomagnetic secular variation, which temporarily causes considerable divergences from an axial field.

It may be concluded that strong evidence now exists that considerable polar wandering has occurred throughout geological time. These results appear to dispose of the possibility that since pre-Cambrian times the continents of America have drifted any appreciable distance from the continents of Europe and Africa. Whether any such continental drift has occurred must await refinement of the accuracy of the measurements. I am indebted to Mr. G. Turnbull and Mr. J. C. Belshe for much help in the measurements and computations.

Details of this work will be published in the *Bulletin of the Geological Society of America*.

S. K. Runcorn
Department of Geodesy and Geophysics,
Cambridge,
and
Museum of Northern Arizona,
Flagstaff, Arizona.
June 14.

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Palæomagnetic Measurements of the Keweenawan

Recently, it has been possible to collect specimens from the Keweenawan system and measure their directions of magnetization. This system is a thick sequence of late Pre-Cambrian volcanics and sediments which outcrop along the margins of the Lake Superior syncline. It is divided into three series, Lower, Middle and Upper Keweenawan. At the type locality on the Keweenawan Peninsula, where most of the specimens were collected, only the Middle and Upper series are represented. Here the Middle Keweenawan consists of 11,000 ft. of basalt and andesite flows known as the Portage Lake Lava Series. There is a total of about three hundred successive flows with occasional interstratified layers of rhyolitic conglomerates and thin beds of sandstone. Succeeding the Portage Lake Lava Series conformably is the Upper Keweenawan, which consists of three divisions. The lowermost is the Copper Harbor Conglomerate, which consists principally of very coarse conglomerates and subordinate amounts of coarse reddish sandstone, but there are also some 500 ft. of interbedded lava flows. The total thickness of the Copper Harbor Formation is 4,500 ft. Lying conformably above the Copper Harbor is the Nonesuch Shale, which in this region consists of 700 ft. of thin bedded sandstones and siltstones. It grades upward into the third of the three divisions of the Upper Keweenawan, the Freda Sandstone. This formation consists of reddish, fine-grained sandstones and siltstones. It is well bedded and consolidated, and usually only shows cross-bedding on a very small scale. One can find ripple marks, mud cracks and raindrop imprints, which clearly indicate a terrestrial deposition. On the Keweenawan Peninsula the Freda Sandstone is approximately 2,500 ft. thick, but in other localities it may reach a thickness of as much as 12,000 ft.

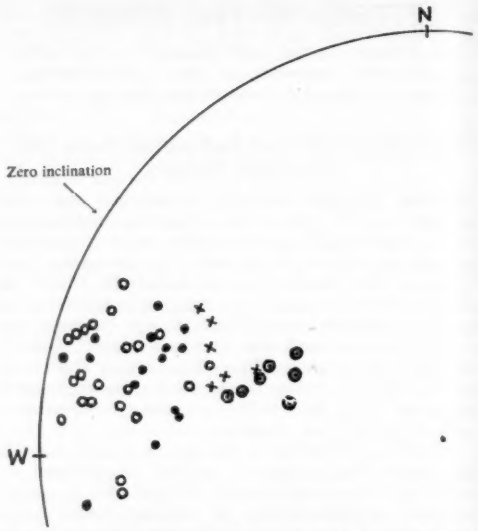

Fig. 1. •, North pole downwards for Freda and Nonesuch; ○, north pole upwards for Freda and Nonesuch; ×, north pole downwards for sandstones in Copper Harbor; ○, north pole downwards for lavas of Copper Harbor and Portage Lake

The structure of the Keweenawan System in this general region is very simple. It is a monocline the eastern boundary of which is marked by the Keweenawan Fault and which disappears under Lake Superior to the west. The strike is north-north-east and the dip ranges from 60° near the fault to 20° close to the shore of the lake. Although the samples were mostly collected from the Keweenawan Peninsula, some specimens were taken near Freda some twenty-five miles to the south-west, where the strata are practically flat-lying. Furthermore, a limited number of samples were collected along the Montreal River, which forms the boundary between Wisconsin and Michigan about a hundred miles to the south-west. Here the strata are steeply tilted with a dip of 70°–80°.

The results of preliminary measurements, corrected for geological dip, are shown in the accompanying portion of a stereogram (Fig. 1). So far, only a small number of specimens have been measured, but one can see that the directions are quite consistent with one another.

The first fact that one notices is that the directions of magnetization are quite different from that of the present earth's field. The second is that the inclinations and, to a much lesser degree, the declinations of the lavas are different from those of the sediments. The first is interpreted as a shift in the geographical pole, in much the same manner as Creer, Irving and Runcorn[1] have interpreted their results obtained from the measurements of pre-Tertiary rocks of Great Britain. For the results from the Nonesuch and Freda formations the pole has been calculated to have been in the Pacific Ocean at long. 165° E., lat. 20° N. Creer[1] has calculated a pole for Lower Cambrian time based on his measurements of the Caerfai Series in Wales, and this pole is located at long. 170° E., lat. 15° N. Thus one can see that there is close agreement between the two, and this agreement suggests the upper part of the Keweenawan is very close to Lower Cambrian in age. This suggestion has often been made by geologists familiar with this region[2].

One would be tempted to attribute the smaller magnetic inclinations of the sediments to the action of sedimentation and compaction. This certainly seems to be the case in the Copper Harbor Conglomerate sandstones, which show an inclination approximately 10° smaller than the lavas above and below them. However, it is difficult to see how these processes could create two almost equal groups of positive and negative dips, which one finds for the formations above the Copper Harbor. Since the mean inclination for the upper sedimentaries is almost 0°, one would expect processes of sediments to have had little or no effect on the value of this mean inclination. Thus it seems that the Copper Harbor sandstones have an inclination smaller than the lavas because sedimentary rocks are unable to reproduce moderate inclinations, but that the mean inclination of the overlying Nonesuch and Freda formations is a true representation of the field at that time. This interpretation means that between Copper Harbor time and Nonesuch time the inclination of the magnetic field changed about 40°, corresponding to a shift of the poles 25° westward. Therefore if the polar wandering was slow and continuous, quite a long period of non-deposition must be represented by the conformable contact of the Nonesuch and Copper Harbor formations. On the other hand, there may have been a sudden and quick change of the pole and continuous deposition.

P. M. Du Bois

Department of Geodesy and Geophysics,
University, Cambridge.
June 7.

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Circular Polarization of Gamma-Rays following Polarized Neutron Capture

An experiment has been carried out in order to verify that the capture of polarized thermal neutrons may result in the emission of circularly polarized γ-rays, as first proposed by O. Halpern[1]. It can be shown that neither linear polarization nor anisotropic distribution of the γ-radiation can result from the reaction[2].

For total neutron polarization, the degree of left circular polarization of the γ-rays emitted in the direction of the neutron spin is[2]:

$$P_\gamma = 2\,(J_c - J_i)\,\frac{L\,(L+1) + J_c(J_c+1) - J_f(J_f+1)}{L\,(L+1)\,(2\,J_i+1)} \quad (1)$$

where J_i, J_c and J_f are initial, compound and final spins of the neutron and L is the multipole order of the γ-ray. If J_i and P_γ are exactly known, it will, in most cases, be possible to determine J_c, J_f and L unambiguously.

The properties of the γ-ray polarization analyser are given by the left circular polarization, P_γ, of the outgoing beam when the incident beam is unpolarized. The γ-ray intensity measured during the experiment is:

$$I_\gamma = c(1 + P_n P_\gamma P_\gamma) \quad (2)$$

where P_n is the polarization of the neutrons being captured in the (n,γ)-target and c is a constant.

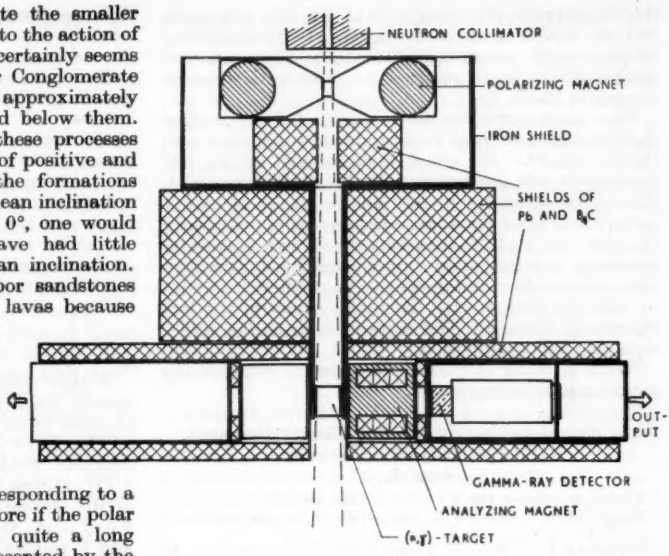

Fig. 1

The experimental arrangement is shown in Fig. 1. Thermal neutrons from JEEP are collimated and partially polarized by transmission through 18 mm. of strongly magnetized iron. The polarized beam falls upon the (n,γ)-target. γ-Rays are detected by two sodium iodide (thallium) crystals after transmission through pieces of iron 8 cm. long magnetized in the direction of transmission. The total cross-section for magnetized iron is a function slowly varying with γ-energy and dependent upon magnetization direction[4]. At magnetic saturation the cross-section for 8-MeV. circularly polarized γ-rays is:

$$\sigma = \sigma_0\,(1 \pm 0{\cdot}0145) \quad (3)$$

where σ_0 is the ordinary cross-section and the sign depends upon whether magnetization is parallel or antiparallel to the propagation vector.

During the measurements, P_n was kept constant, and P_γ was changed every third minute by reversing the current in the analyser magnets.

Four different γ-rays were studied, all of high intensity compared to the rest of the spectrum and all representing transitions to the ground-state or to a very low-lying state. Therefore, no great difficulties were encountered in selecting them by discrimination. Still, disturbing effects like background and scattering in the target were large. Great care had to be taken in order to make the sensitivity of

Table 1. Data for the Four Gamma-Rays Studied

Target nucleus	E_γ (MeV.)	Known spin values J_i	J_c	J_f	L	Observed $\lvert P_n \rvert . P_\gamma$	Derived
^{63}Cu	7·91	3/2		1	1	0·061±0·027	Gamma-ray mainly from $J_c=2$
^{56}Fe	7·64	0	1/2		1	0·063±0·050	$J_f=1/2$
^{61}Zn	7·88	0	1/2			−0·050±0·042	$J_f=5/2$, $L=2$ or $J_f=3/2$, $L=1$
^{58}Ni	9·00	0	1/2	3/2	1	−0·026±0·020	

the photomultiplier independent of the polarizing and the analysing magnetic fields. As the polarizing effect is very small, several months of continuous measurements were required to obtain the results quoted in Table 1.

The 'known spin values' are found from nuclear shell theory and from measurements by Kinsey and Bartholomew[5]. No exact measurement of P_n has been made, but it is estimated to be about 8 per cent. The errors given are mainly due to statistical variations. It is clear from these measurements that only the sign of $|P_n|.P_\tau$ can be quoted with certainty. However, for the simple cases considered, this sign was sufficient for the determination of a few properties by use of equation (1). These are given in the last column of Table 1. The capture in nickel-58 serves as a test for the method.

Work is being carried on in order to improve the experimental arrangement.

Georg Trumpy
Joint Establishment for Nuclear Energy Research,
Kjeller pr. Lillestrøm, Norway.
June 3.

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Hydromagnetic Waves in Ionized Gas

Recent theoretical studies of hydromagnetic (or magneto-hydrodynamic) disturbances in ionized gas suggest that they may play a major part in the physics of some stellar atmospheres and interstellar *H*II regions. Such disturbances, including shock as well as weak hydromagnetic waves, provide a likely explanation of flares, coronal heating and other solar phenomena; their application to the theory of cosmic ray formation is well known.

Previous studies of hydromagnetic disturbances have, for simplicity, assumed a medium with perfect[1,2] or isotropic[3] conductivity. This assumption hides the nature of the electromagnetic field associated with the mechanical disturbance and so fails to reveal some of the most important properties of the phenomenon. Aström[4] and Ginzburg[5] have made further extensions but at the cost of introducing alternative restrictions.

There is a fundamental equation describing the electromagnetic field in a moving isotropically conducting medium (see, for example, ref. 6, equation 2.6 *et seq.*). It includes, among other special cases, the wireless 'telegraph' equation and leads directly and simply to hydromagnetic waves. A corresponding equation for weak disturbances in anisotropically conducting media has now been derived[7]. When only electron conductivity is important and displacement current is neglected it has the form

$$\nabla^2\mathbf{H} = 4\pi\sigma_3\left\{\frac{\partial\mathbf{H}}{\partial t} - \text{curl}\,(\mathbf{v}\times\mathbf{H})\right\} + \frac{\sigma_2}{\sigma_1}\frac{\partial}{\partial z}\,\text{curl}\,\mathbf{H}$$

The steady magnetic field $\mathbf{H}_0$ is parallel to the z axis, and the conductivity components σ_1 and σ_2 (Hall conductivity) are perpendicular to $\mathbf{H}_0$ and to one another; $\sigma_3 \equiv \sigma_1 + \sigma_2^2/\sigma_1$ and for the gas concerned $\sigma_2 = \sigma_0$ the conductivity along $\mathbf{H}_0$. When heavy ions contribute to the conductivity (as in ionospheric region *E*) a term in $(1 - \sigma_3/\sigma_0)$ is added. This equation has been used to develop a theory of weak hydromagnetic waves somewhat analogous to the well-known magneto-ionic theory of radio waves.

Three distinct hydromagnetic waves may, in general, be propagated[2]. Two of these, which we call the ordinary (*O*) and extraordinary (*E*) hydromagnetic waves, are identical with the two corresponding radio waves found in the magneto-ionic theory. The latter are limiting cases, when heavy-ion motion becomes unimportant. The third wave resembles a sound wave and is called the *S* wave. The properties of the three waves depend on the relative intensities of the 'magnetic pressure' $H_0^2/8\pi$ and the gas pressure p and are briefly described for the two conditions

$$\frac{H_0^2}{8\pi} \gg p \text{ and } \frac{H_0^2}{8\pi} \ll p$$

A right-handed system of axes has Oz along the steady magnetic field and the wave normal in the xz plane at an angle θ to Oz. The angular frequencies of the wave and the heavy ions (gyrating in the magnetic field) are ω and Ω respectively.

(1) $H_0^2/8\pi \gg p$. The velocities and polarizations of the *O*- and *E*-waves are complicated functions of θ and ω/Ω. When $\omega/\Omega \ll 1$ the velocities are $V\cos\theta$ and V respectively, where $V^2 = H_0^2/4\pi\rho$ and ρ is the gas density. The waves are then nearly plane polarized along Oy and $O\zeta$ (in the phase plane and perpendicular to Oy). They are only circularly polarized[6] for vanishingly small values of θ. The electric polarization is such that $E_z \sim 0$ and $E_x/E_y \sim H_y/H_x$. The Poynting vectors are nearly along Oz and the wave normal. The gas velocity components are $v_z = 0$ and $v_y/v_x = \cos^2\theta\ H_y/H_x$, movement being in elliptical orbits.

The third or *S*-wave has velocity $U\cos\theta$, where U is the velocity of sound. The magnetic and electric perturbations are nearly along $O\zeta$ and Oy, the Poynting flux along the wave normal and the gas velocity along Oz.

(2) $H_0^2/8\pi \ll p$. When $\omega/\Omega \ll 1$ both the *O*- and *E*-waves have velocities $V\cos\theta$ and are circularly polarized. The electric field is given by $E_z \sim 0$ and $E_x/E_y = \pm i\cos\theta$ and the Poynting vectors rotate on a cone touching Oz and the wave normal. The gas velocity vectors lie in the phase planes, rotating with constant amplitude in the same direction and in contraphase with the magnetic vectors.

The *S*-wave has velocity $\sim U$ and magnetic and electric vectors along $O\zeta$ and Oy respectively. The Poynting flux and gas velocity are along the wave normal, the wave being in effect a slightly disturbed sound wave[2]. In all the waves described above the absorption is determined by σ_3 ($\equiv \sigma_0$) rather than σ_1 or σ_2.

The results given above have been extended to strong (or shock) hydromagnetic disturbances, which will be discussed elsewhere.

J. H. Piddington
Division of Radiophysics,
Commonwealth Scientific and
Industrial Research Organization,
Sydney.
May 20.

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Expansion and Deterioration of Ceramic Bodies

During an investigation of local occurrences of expansion of brickwork and deterioration of roofing tiles we have found that:

(1) Kiln-fresh bricks and tiles taken from representative works in Melbourne all expanded irreversibly on exposure to moisture or even to the atmosphere. Bricks expanded linearly on soaking in water from 0·04 to 0·18 per cent, and tiles on autoclaving from 0·08 to 0·57 per cent.

(2) The degree of expansion, which is characteristic of each brick or tile works, apparently depends not so much on the firing temperature (although the rate of expansion is greater in bricks fired at lower temperatures) as on the composition of the raw material. Cream bricks and light-coloured tiles, both richer in kaolin, expanded more than dark ones.

(3) Tiles in use deteriorate predominantly on protected parts, for example under overlaps, which remain moist for long periods. After years of service they contain about 0·7 per cent of water lost above 110° C., which is of the same order as that of the autoclaved tiles.

(4) The small amount of sodium (0·32–0·52 per cent) present in unaffected tiles is largely, if not completely, replaced by calcium in affected parts.

(5) One badly deteriorated tile, about thirty years old, contains a crystalline calcium zeolite.

(6) The type of tile and brick which deteriorates most in use is similar to that which expanded most in our experiments.

That ceramic bodies expand on contact with water is no new observation, for expansion of bricks[1,2], structural tiles[3], sewer pipes[3] and other ceramic bodies[4] has already been reported. Keppeler and Aurich[5] concluded from indirect evidence that the expansion on rehydration of whiteware fired above 950° C. was due to the formation of permutites (amorphous zeolites). Hill[6], when studying the rehydration of fired clay minerals, identified a crystalline zeolite in rehydrated sodium vermiculite. In the X-ray diffraction patterns of some of the other materials he found weak, extra, unidentifiable lines from which he inferred the presence of poorly crystalline zeolites. It is significant that the temperature (1,050° C.) at which Hill found the greatest expansion of kaolinite (after destruction of its lattice) is close to that (approximately 1,060° C.) at which Delimarskiĭ[7] prepared substances from various mixtures of soda, kaolin and quartz, which disintegrated on hydration and formed permutites. These results indicate that glassy material that is found in well-fired ceramic bodies is likely to form permutites on rehydration, particularly when originating from kaolinitic clays containing soda. The glass expands on forming permutite, when water is incorporated in its structure as hydroxyl ions, and this may cause local stresses. These stresses can lead to disintegration, as we have shown by the autoclaving of soda glass which in hydrating (up to 13·8 per cent water) expanded markedly, but disintegrated so badly that the expansion could not be measured.

The presence of permutites, which have a high cation-exchange capacity, would explain the replacement of sodium by calcium in the deteriorated tiles. The introduction of the slightly larger and more highly hydrated calcium ion into the permutite would cause a secondary expansion of the body such as has been found[2] with bricks, which expanded 0·20 per cent in a solution of a calcium salt compared with 0·05 per cent in water.

We conclude that the expansion on rehydration of ceramic bodies burnt above 950° C. is due to the formation of zeolites, mainly of permutites. The ceramic body may deteriorate as a result of expansion in extreme cases, or as a result of frost or salts attacking the already weakened body.

It has been shown that the irreversible expansion can at least be reduced by the addition of lime[5] or magnesite[4] to the raw clay, and it is likely that barium carbonate also would stabilize the fired body. 'Curing' bricks by stacking them in the open for some time should prevent or greatly reduce expansion after laying. These matters are being investigated.

We are grateful to Drs. J. S. Hosking and W. F. Cole and to Mr. R. D. Hill for their valuable discussions.

H. V. Hueber
Angela A. Milne

Division of Building Research,
Commonwealth Scientific and
Industrial Research Organization,
Graham Road,
Highett, S.21, Victoria.
April 7.

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Stillwellite, a New Rare-Earth Mineral from Queensland

The presence of stillwellite was discovered in 1954[1] during a mineralogical investigation of radioactive ore from the Mary Kathleen Lease, 34 miles east of Mt. Isa in north-western Queensland. At the Lease, stillwellite and allanite occur in quantity, along with garnet and other minerals, as a metasomatic replacement of metamorphosed calcareous sediments. Uraninite is dispersed through both minerals.

Stillwellite is the major constituent of sections of the ore, occurring as crystals up to 5 mm. in diameter. In thin section it is colourless with a birefringence of 0·018–0·020, and is uniaxial positive to biaxial positive with $2V$ up to 6°. Occasional zoning is evident in thin sections and in the variation of the refractive index of the ordinary ray from 1·775 to 1·784 ± 0·003 in sodium light. The stillwellite is thus optically comparable with cerite, from which it differs in having lower refractive indices, and a different X-ray powder pattern.

The preliminary analysis of a concentrate containing 96–98 per cent stillwellite totals 100·30, and gives as major constituents Ln_2O_3 58·4, B_2O_3 11·5, SiO_2 20·1, CaO 3·96, P_2O_5 2·58 per cent. Cerium oxide (Ce_2O_3) constitutes 51 per cent of the total lanthanon oxide, which contains not more than 5 per cent of heavy lanthanons.

An X-ray single-crystal study shows that stillwellite is hexagonal, rhombohedral, with space group $C3m$, $C3_m2$ or $C\bar{3}m$, a unit cell of dimensions

$a = 6{\cdot}85$ A, $c = 6{\cdot}64$ A., and an axial ratio $a : c$ of 1·032. Allowing for the presence of a small amount of a phosphate mineral in the concentrate analysed, this cell contains close to $3(Ln,Ca)BSiO_5$ for the measured density of 4·57 gm./c.c.

The mineral is named in honour of Dr. Frank Leslie Stillwell, former chief of the C.S.I.R.O. Mineragraphic Investigations, who has contributed so notably to the knowledge of Australian ore deposits and who initiated the study of ore minerals in Australia.

A detailed report will be published elsewhere.

From another source, the discovery of a "boron-bearing variety of cerite" in Mary Kathleen ore was announced in the Adelaide *News* of May 20, 1955.

J. McAndrew
T. R. Scott

Commonwealth Scientific and
Industrial Research Organization,
Melbourne.
May 30.

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Plasticity of Wool

The marked variations in plasticity among the fibres of a single staple of wool[1] are now known to be associated with the types of follicle from which they are derived, fibres with the lowest plasticity being produced by primary central follicles, which are the first to develop, and fibres with the highest plasticity by the secondary follicles which are the last to develop[2]. It has, however, proved more difficult to identify the chemical and physical causes of the variations in plasticity. With two wools, which were examined in great detail, fibres with the lowest plasticity were found to have the highest sulphur content, and vice versa[1,2], as would be expected if unfolding of the main chains of α-keratin during plastic flow is impeded by cystine cross-linkages; but the simplicity of the relationship appears to be marred in other cases by differences in the mode of distribution of cystine in different fibres.

A rule of more general validity has, however, emerged from studies of the relationship between the plasticity of fibres and the proportion of ordered (crystalline) material they contain. The observation that there is an inverse relationship between plasticity and crystallinity in the case of New Zealand Lincoln wool[3] has now been confirmed with a wide range of New Zealand Romney, Australian merino and South African merino wools. Not only so, but also the physical and chemical causes of variations in plasticity among the fibres of a single staple appear to be linked, as is shown by the following determinations of the plasticity and tyrosine content of fibres from single staples of two New Zealand Romney wools.

Fibres from primary lateral follicles (early curly-tips) and secondary follicles (long histerotrichs) were selected from a single staple in the usual way[2]. Each fibre was allowed to extend about 55 per cent in water at 22·2° C. under a load of 700 kgm./cm.[2]. On being released, the fibre returned to its original length, and its plasticity (k) was calculated from the extension/time curve[1]. The eight early curly-tips with the lowest plasticities and the eight histerotrichs with the highest plasticities were then iodinated with iodine-131 under conditions which are known to convert almost all (96 per cent) of the tyrosine side-chains into 3 : 5-di-iodotyrosine[4]. After the fibres had been freed from loosely combined iodine by treatment with sodium thiosulphate solution and washing, radiophotographs were prepared in the usual way[4]. The tyrosine content of each fibre was then estimated by measuring the optical density of the radiophotograph at intervals along the length and correcting for the variations in cross-sectional area of the fibre. The results are given in Table 1.

Table 1

Wool No.	Type of fibre	Average diameter (μ)	Average plasticity, ($k \times 10^{-5}$)	Tyrosine content (arbitrary units)
1	Early curly-tips	40·7	28·7	6·4
	Long histerotrichs	28·8	67·6	10·9
2	Early curly-tips	39·0	49·7	6·1
	Long histerotrichs	28·4	77·9	9·0

In both cases the more plastic fibres contain the greater amount of tyrosine, and since the more plastic fibres are also the more amorphous, it seems clear that the bulky side-chains of tyrosine are one cause of main-chain disorder in wool, just as in the case of silk.

P. L. le Roux
J. B. Speakman

Textile Chemistry Laboratory,
Department of Textile Industries,
University, Leeds.
July 18.

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Theory of Antibiotic Inhibition Zones in Agar Media

Since Cooper and Woodman[1] proposed on theoretical grounds that the formula

$$x^2 = 4\,DT_0\,2{\cdot}30\,(\log m_0 - \log m')$$

should explain the size of inhibition zones, under specified experimental conditions, evidence on the validity of this proposal has been accumulated by many workers. The variables in the formula have been further analysed, and it is now possible to give an extended explanation of their meaning, which should give a more accurate understanding of the factors influencing the size of inhibition zones.

The original formula was concerned with the diffusion of an antibiotic having a diffusion coefficient D, from a solution kept at a constant concentration m_0, into an agar culture of an organism (Fig. 1).

The time at which the critical concentration m' reached the edge of the zone of inhibition can be

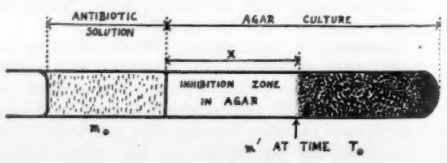

Fig. 1

calculated for all values of x (zones of different sizes) and is given by

$$T = x^2/4\,(D\,2{\cdot}30\log m_0/m') \qquad (1)$$

It was shown experimentally that a critical value of T existed in the growth of the bacterial population, when the edge of the zone was formed; for if the organism is incubated for h hr. before adding the diffusing antibiotic, the size of the zone is reduced. This critical value was called T_0, because if the time of preincubation of culture h is T_0, the zone was reduced to nil. The size of zones for varying values of h was given by putting $T = (T_0 - h)$ in (1), and when $h = 0$, $T = T_0$.

Cooper and Linton[2] examined the factors influencing T_0, and showed the importance of temperature control in the early hours of growth. They explained experimental anomalies in the use of plate cultures. Temperature control was much more certain by using the tube method of Mitchison and Spicer[3], and therefore Cooper and Gillespie[4] used this method to investigate its influence on T_0, in the case of streptomycin acting on staphylococcus. Over a wide range (22°–42°) the variation in T_0 from 2·2 hr. to 9·0 hr. was explicable by:

$$T_0 = L + n'G \qquad (2)$$

where L is the lag period, and G the generation time of the organism in the nutrient medium at the temperature of the experiment; n', the number of generations at time T_0, was remarkably constant (3·5–4·4) over the whole temperature range, when a standard inoculum and a standard medium were used.

Cooper[2] pointed out that the slope of the graphs of Mitchison and Spicer[3] with different sizes of inocula were empirically related to the inoculum size (N_0). Though the relationship suggested with $\sqrt[3]{N_0}$ was only an approximation without theoretical foundation, it prompted us to examine this more closely. As a result, it is now possible to give a theoretical basis to the meaning of T_0 and calculate its value from the growth curve of the organism. The effect of inoculum size observed by Mitchison and Spicer[3], and further investigated by Linton[5], can be even more accurately predicted.

The theory of the early part of the growth curve is well known. Let N be number of organisms at time T, N_0 their number at zero time, n be the number of generations, G be the generation time. Then $N = N_0\,2^n$ and $T = L + nG$.

In solid media, the number of organisms per colony is given by $p = N/N_0 = 2^n$, or $n = \log_2 p = \log_2 N/N_0 = 3{\cdot}32\log_{10} N/N_0$. Therefore, $T = L + 3{\cdot}32\,G\,(\log N/N_0)$. When $T = T_0$, let the value of N be N' and the value of n be n'. Then

$$T_0 = L + n'\,G = L + 3{\cdot}32\,G\,(\log N'/N_0) \qquad (3)$$

The first part of this equation is identical with equation (2), which was derived experimentally. It is now evident that n' is the number of generations required to reach a critical density of organisms per ml., and that T_0 varies with both temperature and size of inoculum to allow this to be done.

Combining equation (3) from the growth-curve of the organism with equation (1) from the diffusion laws, we have:

$$x^2/4\,D\,(2{\cdot}30\log m_0/m') = T_0 = L + 3{\cdot}32\,G\,(\log N'/N_0)$$

or

$$x^2 = 4\,D\,(2{\cdot}30\log m_0/m')\,(L + 3{\cdot}32\,G\log N'/N_0)$$

This explains the effects of inoculum density, so long as allowance is made for the possible effect of high values of N_0 on lag period and generation time (not detectable in Mitchison and Spicer's results). The values m' and N' depend on the antibiotic and the organism, but the other symbols represent variables all of which can be separately determined and controlled. Even D depends on the viscosity and temperature. It is felt, therefore, that the critical density of organisms N', which represents a limiting factor for inhibition of growth, is just as important as the critical concentration of antibiotic m', which must be reached before N', in order to form a zone. The critical time T_0 is the time required by the inoculum N_0 to multiply at a rate of $1/G$, in order to reach the population N'. The edge of the zone at distance x is decided by the fact that the critical concentration m' must reach there before the bacterial population exceeds N'. The amount of bacterial cells is evidently just as important as the amount of antibiotic.

The theory, with appropriate modifications, should be applicable to zones of exhibition in vitamin assay work, as well as zones of inhibition due to antiseptics. An understanding of its principles should enable the detection of other factors influencing results to be made more easily (for example, variations in the sensitivity of the organism; the influence of nutritional and toxic factors in the medium; antagonism and synergism with other substances). In the case of streptomycin and the staphylococcus, the presence of magnesium and iron ions in the agar medium influenced the critical concentration m' and hence the size of the zones (Linton[6]). With constant medium, however, m' and N' have been constant, within the experimental error, for the action of streptomycin on staphylococcus, for all temperatures and all densities of inoculum. With chloramphenicol, temperature affects the action of the antibiotic, giving a change in m'—and possibly N' may be slightly affected, though the result is on the borderline of the experimental deviations.

K. E. Cooper

Department of Preventive Medicine,
University of Bristol.
April 22.

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Effect of Anti-histamine Substances on Cold Vasodilatation in the Finger

Lewis[1] described an intermittent vasodilatation in the finger during its immersion in cold water, and suggested that a histamine-like substance was released in the cold tissues.

In order to study the part played by histamine in bringing about this response, the antihistamine substances diphenhydramine hydrochloride ('Benadryl') and promethazine hydrochloride ('Phenergan') were administered to normal, heat-acclimatized, Asian subjects, whose cold vasodilator responses were followed by means of copper-constantan thermocouples strapped to their index fingers. In each case the skin temperature of the finger was plotted against

Table 1

Treatment	No. of subjects	Area of cutaneous histamine wheal (sq. mm.)	Graphic representation of cold vasodilator response (sq. cm.)	Treatment	No. of subjects	Area of cutaneous histamine wheal (sq. mm.)	Graphic representation of cold vasodilator response (sq. cm.)
Dummy by mouth	4	11·4	37·5	'Benadryl' (50 mgm.) by mouth	4	8·5	37·3
Dummy by mouth	7	10·8	43·8	'Phenergan' (50 mgm.) by mouth	7	3·9	25·6
Iontophoresis of 0·9 per cent saline	3	—	46·9	Iontophoresis of 2·0 per cent 'Phenergan'	3	—	57·5

time and the results expressed (1) as the mean area enclosed by this curve[2], and (2) as the latent period of the response[3]. A 1/1,000 solution of histamine acid phosphate was placed on the skin of the forearm of the same subjects and a needle-prick was made through the solution. The mean area of the wheal thus produced was measured immediately before each cold immersion.

The results are given in Table 1. 50 mgm. of diphenhydramine hydrochloride, by mouth, reduced the size of the cutaneous histamine wheal ($t = 2{\cdot}21$, $p < 0{\cdot}20 > 0{\cdot}10$) but had no effect on the cold-vasodilator response. 50 mgm. of promethazine hydrochloride given by mouth caused a highly significant reduction both of the histamine wheal ($t = 11{\cdot}473$, $p < 0{\cdot}001$) and of the cold vasodilator response ($t = 3{\cdot}831$, $p < 0{\cdot}01 > 0{\cdot}001$) and it also significantly delayed the onset of the vasodilator response ($t = 3{\cdot}628$, $p < 0{\cdot}01 > 0{\cdot}001$). There was a reflex vasodilator reaction in the index finger of the opposite hand, and this response was also significantly delayed by the oral administration of 50 mgm. of promethazine hydrochloride ($t = 3{\cdot}357$, $p < 0{\cdot}02 > 0{\cdot}01$). When introduced into the fingertip by iontophoresis, promethazine hydrochloride increased the magnitude of the cold vasodilatation, a result compatible with the local anæsthetic action of promethazine hydrochloride[4,5]. In ten untreated subjects a negative correlation was found between the size of the cutaneous histamine wheal and the magnitude of the cold vasodilatation ($r = 0{\cdot}705$, $p < 0{\cdot}05 > 0{\cdot}02$).

Since systemic administration of promethazine hydrochloride causes central depression[6,7], and since local administration of promethazine hydrochloride did not inhibit the cold vasodilator response, it seems possible that inhibition of the response by the oral administration of 50 mgm. of this drug was due to a central depressant action. These results provide, therefore, no definite evidence for the participation of histamine in the cold vasodilator-response, and this conforms with observations by Duff *et al.*[5].

Experiments are now in progress to investigate the effect of drugs with a central depressant action on the cold vasodilatation in the finger.

G. C. Whittow

Department of Physiology,
University of Malaya,
Singapore.
June 2.

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Effect of Vagal Stimulation on the Sinus Venosus of the Frog's Heart

The effect of vagal stimulation or applied acetylcholine on electrically driven heart auricle fibres has been studied with intracellular electrodes by several workers[1]. The purpose of the present experiments was to gain some information about the events during vagal inhibition in spontaneously active pacemaker fibres.

The sinus venosus of a frog's heart was excised together with the two vago-sympathetic nerves, cut open and pinned out. When an electrode was inserted into the region where the beat could be observed to start, a typical pacemaker potential[2] was seen: the membrane potential decreases slowly throughout diastole until the threshold for an action potential is reached. In fibres that showed constant pictures for several beats, the most negative value of the membrane potential during the cycle ranged from 45 to 60 mV.

If the vagi are stimulated briefly during the falling phase of an action potential, the repolarization proceeds to above the most negative point reached in previous cycles, and the next beat is delayed because the slope of the pacemaker potential is reduced (Fig. 1*A*, left). With more prolonged stimulation a slow 'hyperpolarization' suppresses the next pacemaker potential and stops the heart (Fig. 1*A*, right). On removing the vagal stimulus a slow depolarization develops again. In the experiment illustrated, this depolarization was not allowed to reach the threshold; instead, a second train of vagal impulses was sent into the preparation, causing a renewed hyperpolarization. After this procedure was repeated once more, an action potential of shortened duration arose from a now apparently reduced threshold. The maximum increase of the membrane potential, as measured from the foot of the last pacemaker potential, was 8 mV. in this experiment.

In twelve other experiments, the inhibitory hyperpolarization measured 3–13 mV. (mean 8 mV.). On several other sinus fibres, however, vagal stimulation merely depressed the pacemaker potential (Fig. 1*B*). This suggests that the transition from a typical pacemaker to a typical auricle fibre is gradual. It is noteworthy that the first two action potentials after the vagal arrest are not only shortened, but also slightly decreased in amplitude. This reduction of the 'overshoot' amplitude was usually observed, and was particularly striking on occasions when impulses reached the inhibited fibre from an accidentally denervated and still beating part of the sinus.

The events underlying the increase in beat frequency on sympathetic stimulation were studied in a few atropinized preparations. As might be expected, the pacemaker potential increased in steepness after a latent period of several seconds (Fig. 1*C*). The

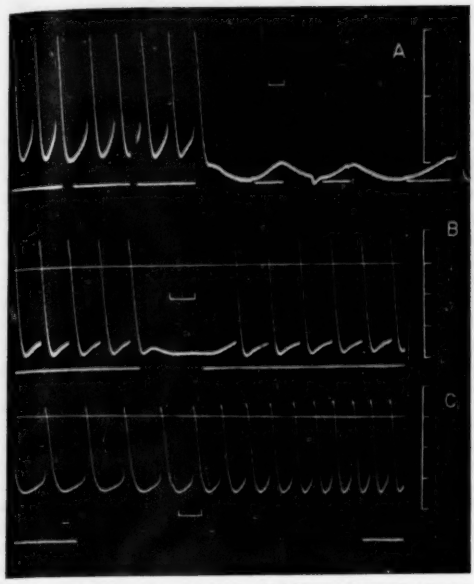

Fig. 1. Intracellular records from the sinus venosus of a frog's heart. Vagal stimulation indicated by breaks in the lower beam. (*A*) Vagi stimulated at 10 per sec. during the repolarization of the third action potential. During the eighth action potential, vagal stimulation starts again (see text). Gap after fifth action potential denotes interval of several seconds. (*B*) Depression of pacemaker potential without hyperpolarization. This preparation was treated with ergotamine, 1 in 10^6. (*C*) Effect of vago-sympathetic stimulation in an atropinized preparation.

Voltage calibration in 20 mV. steps; in (*B*) and (*C*) a line is drawn through zero potential; in (*A*) calibration from −10 mV. downwards. Time: 1 sec.

'overshoot' was increased from 5·5 mV. to 11 mV. on sympathetic stimulation.

These results confirm the results of Gaskell[3], who found that the demarcation potential in turtle auricle was increased during vagal inhibition. They also call to mind the experiments of Howell and Duke[4], and of Lehnartz[5], who showed that during vagal arrest a heart liberated potassium ions; for an outflow of potassium ions could contribute to the inhibitory hyperpolarization. An increase in permeability to potassium, relative to that of sodium, could also account for a decrease in the 'overshoot' and for the faster repolarization of the action potential.

O. F. Hutter
W. Trautwein

Wilmer Institute,
The Johns Hopkins Hospital and University,
Baltimore, Md. April 20.

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Nutritive Value of Heated Vegetable Oils

Much of the fat consumed by human beings, particularly in India, has been heated, and the conditions of heating vary widely and also with the nature of the foodstuff into which the oil or fat is incorporated. It is therefore necessary to have scientific data concerning the nutritive value of heated oils and fat.

Heated oils have been shown to be poorly absorbed[1], to produce cancerous tumours[2] and to cause paralysis resembling that due to vitamin E deficiency[3]. Thermal polymerization was found to develop toxic products responsible for growth depression[4]. Kaunitz[5] stated that oxidized fats destroyed vitamins in the diets and thus caused retardation of growth. Chalmers[6] found that injections of heat-polymerized cotton-seed oil did not lead to the growth of tumours.

In most of the above investigations, the oils were heated in a current of carbon dioxide or nitrogen. In India, oils are heated in open pans for long periods and, further, the residual oil from a day's operations is supplemented with fresh oil and re-heated again. This may accelerate the oxidative and other changes. The work reported in this communication was undertaken to elucidate the nutritive value of some of the commonly used oils when they were fed after heating.

Groundnut, sesame and coconut oils were heated in an open iron pan at 270° C. for 8 hr. They were then incorporated into synthetic diets to give 15 per cent fat, and fed to albino rats. There were six groups of six rats each, five weeks old and weighing 40–50 gm. The two groups of rats allotted to any particular oil (unheated and heated) were litter mates and were distributed with due consideration to weight and sex. The diet employed had the following composition: fat, 15 per cent; casein, 12 per cent; sugar, 10 per cent; salt mixture, 4 per cent; and starch, 59 per cent; and the vitamin supplements were: thiamine, 15; riboflavin, 60; pyridoxine, 10; niacin, 10; calcium pantothenate, 50 (all in mgm. per kgm. of the diet); and choline, 1 gm. Vitamins A and D were given in the form of two drops of 'Adexoline' twice a week per rat. The rats were housed in independent cages. The vitamin supplements were added to the diet every day, so as to prevent their destruction by the heated oils. Weekly growth records were maintained. At the end of the sixth week, four rats from each group were opened under chloroform, and liver, spleen, stomach and kidney were removed and weighed. The liver fat was also estimated. The observations are presented in Table 1.

Table 1. Influence of Heating the Oil on its Nutritive Value and Fat Deposition in the Liver

	Average gain per rat per week (gm.)	Feed efficiency	Liver weight as percentage of body weight	Percentage fat in liver
Groundnut oil:				
Unheated	13·0 ± 0·5	1·1	3·8 ± 0·3	3·9 ± 0·3
Heated	5·0 ± 0·9	0·67	5·7 ± 0·6	7·1 ± 0·4
Sesame oil:				
Unheated	10·0 ± 0·8	1·0	4·2 ± 0·7	4·8 ± 0·3
Heated	4·3 ± 0·7	0·7	6·0 ± 0·5	7·8 ± 0·3
Coconut oil:				
Unheated	11·0 ± 1·1	1·1	4·3 ± 0·3	4·5 ± 0·3
Heated	4·5 ± 0·7	0·7	5·8 ± 0·4	7·0 ± 0·3

The results show clearly that in all three cases the heated oil has adversely affected the gain in weight. The feed efficiency, that is, the increase in weight per gm. of fat consumed, of the heated-oil group of rats is considerably reduced. There were no significant changes in the weights of stomach, kidney and spleen of the two groups of animals. These results are not, therefore, presented here.

It may be seen that the liver weights (fresh) of the heated-oil groups are significantly higher than the controls. The fat content of the livers of the heated-oil group is nearly twice that of the control groups. Heated oil has produced fatty infiltration of the liver. Further, the livers were badly damaged and congested, and were not of the normal colour.

When the heated oil was fed at 30 per cent level, all the rats died within a week, whereas the control rats were quite healthy. In another set of trials, when 15 per cent heated oil (heated at 280° C.) was used in the diet, severe jaundice occurred and four of the six rats died in the sixth week of the experiment. The exact changes brought about by heating the oil and also the other aspects of the problem are being studied.

Our thanks are due to Prof. K. V. Giri for his interest in the investigation.

N. V. Raju
R. Rajagopalan

Department of Biochemistry,
Indian Institute of Science,
Bangalore 3.
Nov. 23.

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Cessation of Tillering in Young Grass Plants

During the early seedling growth of *Lolium perenne* plants in pots, Cooper[1] noted that the number of tillers per plant increased exponentially with time until some date 60–100 days after sowing, when the initial exponential growth was sharply curtailed and tiller production ceased. This phenomenon has been observed in experiments in which the chief concern

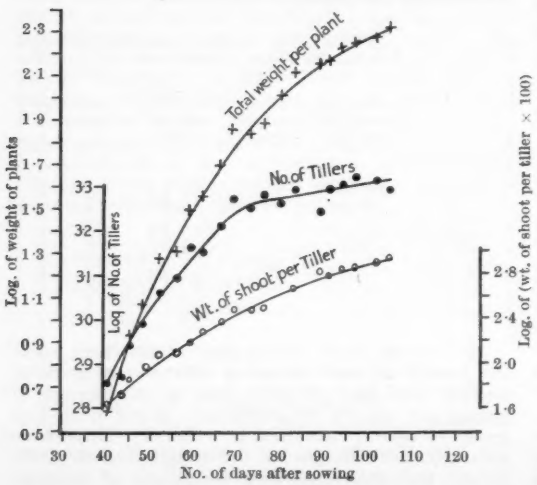
Total weight per plant
No. of Tillers
Wt. of shoot per Tiller
Log. of weight of plants
Log. of No. of Tillers
Log. of (wt. of shoot per tiller × 100)
No. of days after sowing

Fig. 1

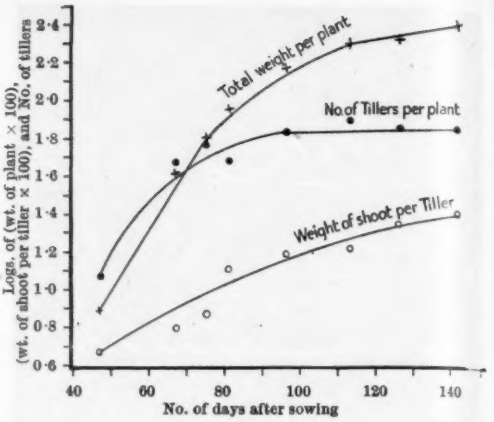
Total weight per plant
No. of Tillers per plant
Weight of shoot per Tiller
Logs. of (wt. of plant × 100), (wt. of shoot per tiller × 100), and No. of tillers
No. of days after sowing

Fig. 2

was with growth as measured by increase in weight. The results obtained in a field experiment where the plants were growing in a sward are summarized in Fig. 1. In this experiment thirty plants of each of twenty-two strains representing seventeen grass species were dug up twice a week, washed free of soil, the tillers counted and then dried and weighed. Each point in the figure is derived from the measurement of 660 plants. In the majority of strains tiller production ceased about the seventieth day after sowing. No sudden change occurred in the rate of increase of the plants (roots plus shoots) or in the rate of increase of the weight of shoot per tiller, that is, the weight of a tiller. Other details of the experiment have been published elsewhere[2].

In another experiment, plants of *Lolium perenne* S.24 were grown in whalehide pots of 6,700 ml. capacity. An equal number of pots containing one, two or three plants were taken at intervals, the plants washed free from soil and then treated as in the other experiment. Usually thirty pots were dealt with on each date. The results are presented in Fig. 2 as the mean of the plants measured on a particular date. Tiller production ceased about the hundredth day after sowing. As in the field experiment, there was no cessation of dry-weight increase comparable to the cessation of tiller production, although a gradual reduction in this rate did occur. The weight of shoot per tiller increased at the same rate throughout the period of the experiment.

This state of inanition of tillering would appear to affect chiefly the meristematic tissues concerned with the production of new tillers; the more mature tissues are unaffected and continued to grow, that is, to gain in weight without any sudden change in the rate of increase for some considerable time after the cessation of tiller production. This is in accordance with Cooper's[3] findings that rate of leaf production on the main tiller was unaffected by cessation of tillering.

Arthur Troughton

Welsh Plant Breeding Station,
University College of Wales,
Aberystwyth.
March 11.

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Temporary Destocking of Pastures to aid Control of the Cattle Tick

THE tick *Boophilus microplus* Can., is generally considered to be the most serious single cause of loss to the cattle industry in tropical Australia, contributing to the death of many cattle in dry years. Present control measures are costly, and by placing undue reliance on frequent dipping are thought to have increased the tendency of ticks to become resistant to BHC and arsenic[1]. A method involving only two or three dippings per year can be expected to reduce the difficulties of controlling strains of ticks resistant to these and newer acaricides. The results of the following 'pilot-scale' experiment carried out near Rockhampton, Queensland, emphasize the possibility of reducing the frequency of acaricidal treatment by destocking the pastures for periods which some cattle owners do not find inconveniently long.

Two herds of cattle were kept in adjoining comparable paddocks of approximately seventy-five acres. An equal number (10–14) of animals was present in each of the two herds at any one time. The 'control' herd was allowed access to the whole area of paddock *C* continuously, whereas the experimental herd was alternated between the two halves, *A* and *B*, of the other paddock, which was divided by an electric fence. The periods for which the *A* or *B* paddocks were destocked were based, after mid-November 1953, on observations made in the district on the time taken from the date of drop of a replete female tick to the death of its larval progeny (Wilkinson, unpublished data). Fig. 1 shows infestations of adult ticks, exceeding 0·5 cm. in length, on the two herds, the numbers with arrows indicating occasions on which the animals were sprayed with DDT preparation (1 per cent *p,p'*-isomer). It will be seen that, after the beginning of February 1954, infestations of the cattle moved to previously destocked pastures remained low. A few ticks continued to occur on the cattle, and this was considered a desirable feature, because the cattle would be regularly re-infested with *Babesia* carried by the larvæ and thus retain their immunity to 'redwater' fever[2].

Destocking of pastures has been practised frequently during tick eradication campaigns, but no experiment on destocking as a control measure has hitherto been described. A fuller account of this work and its application to Queensland conditions will be published elsewhere.

P. R. WILKINSON

Veterinary Parasitology Laboratory,
Division of Entomology,
Commonwealth Scientific and
Industrial Research Organization,
Yeerongpilly, Queensland.

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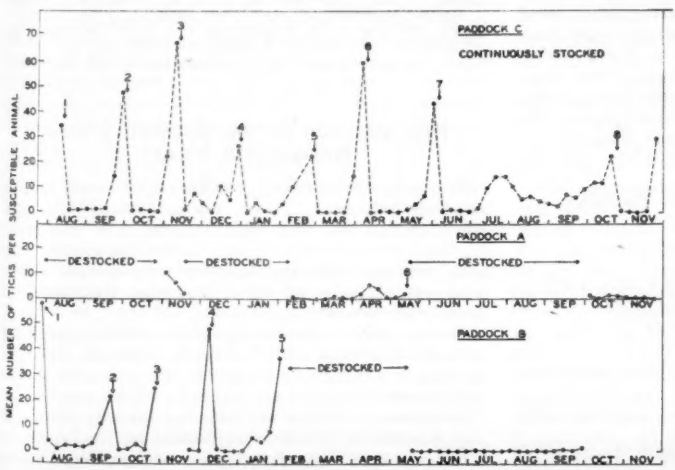

Fig. 1. Comparison of infestations of cattle on a continuously stocked and a pasture spelling paddock. Counts of female ticks, 0·5 cm. and upwards in length, on the right side of the cattle

A New Acaricide, 2,4,5,4'-Tetrachlorodiphenylsulphone

Läuger *et al.*[1], Swingle[3] and Browning *et al.*[3] have stated that the insecticidal value of *p,p'*-dichlorodiphenylsulphone is relatively low; Läuger *et al.*[1] state that diphenylsulphone and monochlorodiphenylsulphone are devoid of any insecticidal activity. On the other hand, Eaton[4] found among various diphenyl compounds some substances with a sulphone link active against spider mites and their eggs; optimal acaricidal activity occurred with mono-*p*-chlorodiphenylsulphone[5].

Diphenylsulphone and mono-*p*-chlorodiphenylsulphone are more or less phytocidal at active concentrations. We have now found that 2,4,5-trichlorodiphenylsulphone ('*V* 17') and 2,4,5,4'-tetrachlorodiphenylsulphone ('Tedion *V* 18') possess strong acaricidal properties without phytocidal side-effects. As can be seen from Tables 1 and 2, the latter substance is more active on the eggs than any of the other compounds listed. As is the case with some newer specific acaricides now in use, such as *CPBS* (*p*-chlorophenyl-benzenesulphonate), *CPCBS* (*p*-chlorophenyl-*p*-chlorobenzenesulphonate) and *p*-chlorophenyl-*p*-chlorobenzylsulphide, 'Tedion *V* 18' also shows activity on all stages except adult spider mites.

The various compounds were tested on *Tetranychus urticae* Koch on bean plants (*Phaseolus*). Potted bean plants with or without eggs were dipped in emulsions containing the active material. After the plants without eggs had dried, these were infected with adult females in order to obtain eggs on the dry residue. After two or three days the adults were removed. In order to evaluate the penetration of 'Tedion' into the leaf, leaves were treated on the upper side and infected with mites on the under side. Solutions and emulsions containing 1,000 and 100 p.p.m. of active material caused in these circumstances a total kill of eggs and larvæ.

The phytotoxic properties of 'Tedion *V* 18' were investigated on seedlings of *Tropaeolum majus*, cucumber, tomato, potato, broad bean (*Vicia faba*), French bean (*Phaseolus vulgaris*) and garden pea (*Pisum sativum*). The plants were thoroughly sprayed with 0·3, 1·0 and 3·0 per cent of active material,

Table 1. Action of *CPBS*, *CPCBS* and 'Tedion' on *Tetranychus urticae* Koch

Compound	Concentration (p.p.m.)	Percentage kill			
		Eggs dipped		Eggs layed on residue	
		Direct kill of eggs	Total kill eggs/larvæ	Direct kill of eggs	Total kill eggs/larvæ
CPBS	100	24	100	74	100
	30	0	100	14	77
	10	0	69	0	0
CPCBS	100	25	100	58	99
	30	7	100	4	38
	10	0	33	8	10
'Tedion'	100	100		100	
	30	100		100	
	10	100		100	

Table 2. Action of *p*-Chlorophenyl, *p*-Chlorobenzylsulphide (Chlorparacide) and 'Tedion' on *Tetranychus urticae* Koch

Compound	Concentration (p.p.m.)	Percentage kill			
		Eggs dipped		Eggs layed on residue	
		Direct kill of eggs	Total kill eggs/larvæ	Direct kill of eggs	Total kill eggs/larvæ
Chlorparacide	100	81	100	100	
	30	64	99	100	
	10	45	72	87	97
	3	10	63	10	42
'Tedion'	100	100		100	
	30	85	100	100	
	10	79	97	100	
	3	37	99	94	98

but no deleterious effect could be noted even after ten days.

'Tedion *V* 18' did not show any visible effect on flies, beetles, aphids and other insects when these were exposed to a dry residual film. Bees were not poisoned by contact or by ingestion of contaminated food. The oral median lethal dose for mice of 'Tedion *V* 18' exceeds considerably 5 gm./kgm., for this dosage did not cause death or any visible symptom of intoxication among the test animals. Therefore it appears to be a highly specific compound which is safe for the operator and the consumer of the treated products.

Other mites are also killed by 'Tedion *V* 18'. Field trials on fruit tree red spider (*Metatetranychus ulmi* Koch) have shown that one post-flowering treatment may keep the orchards practically free of red spider up to the autumn. Successful results have been obtained on apples, pears, plums, cucumbers, grapes, carnations, roses and other horticultural crops in the Netherlands, Belgium, Luxemburg and France.

Details of laboratory and field-trials will be published elsewhere.

H. O. Huisman
N.V. Philips-Roxane
Chemical Research Laboratory,
Weesp.

R. van der Veen
J. Meltzer
Agrobiological Laboratory "Boekesteyn",
's-Graveland. March 22.

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Control of Yeast Contamination by 'Mycostatin' in Cultures of the Virus of Foot-and-Mouth Disease

Culture of the virus of foot-and-mouth disease by Frenkel's method[1], in which the epithelial tissue of the cattle tongue is used, is being widely adopted for the provision of virus for vaccine production. The tongue epithelium is grossly contaminated with bacteria and yeasts, and antibiotics must be included in the culture medium for their suppression. The bacterial contamination that we have encountered has been effectively controlled by penicillin and streptomycin; but the problem of inhibiting the growth of yeasts remained. During December 1954–March 1955, fourteen apparently distinct strains of yeasts have been isolated from virus cultures in which the tongue tissue was from cattle slaughtered in London. An attempt is being made to identify these strains using the classification of Lodder and Kreger-van Rij[2]. This has led, so far, to recognition of species from the genera *Endomycopsis*, *Saccharomyces*, *Sporobolomyces*, *Candida*, *Kloeckera*, *Trichosporon* and *Rhodotorula*.

It has now been found possible to control this yeast contamination by the addition to the culture medium of 'Mycostatin'[3], an antifungal substance from a soil actinomycete originally extracted by Hazen and Brown[4]. In *in vitro* tests, 'Mycostatin' inhibited the growth of thirteen of the above fourteen strains in a concentration of 20 units/ml., and the remaining strain was inhibited by 80 units/ml. The addition of 20 units/ml. to the virus cultures has resulted in complete control of yeast contamination. Using fourfold increases in concentration, no decrease in virus multiplication was observed until 320 units/ml. had been exceeded.

We are indebted to Messrs. E. R. Squibb and Sons for supplies of 'Mycostatin'.

Jacqueline O. Wigmore
W. M. Henderson
Research Institute (Animal Virus Diseases),
Pirbright, Surrey.
June 4.

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Reproduction in the Cat-fish, *Clarias mossambicus* Peters.

No precise information has been published on the breeding habits of *Clarias mossambicus*. Although previous authors who have studied this species in the field give records of ripe females[1] and breeding fish[2], definite spawning sites have apparently never been determined, nor have the eggs, embryos and larvæ been described.

During recent rains in Uganda an actual spawning site was investigated. Spawning took place in the flooded, low-lying areas adjacent to a shallow drainage stream flowing into Lake Victoria, near Jinja. This stream is separated from the lake by a narrow papyrus swamp which is succeeded on the landward side by a thin belt of the grass *Echinochloa*. When not in spate, the stream is reduced to a series of shallow, disconnected pools without direct surface-water connexion with the lake. Under flood con-

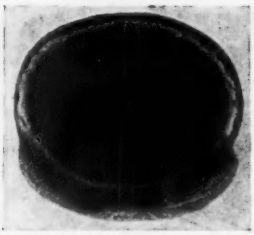

Fig. 1. Fertilized ovum of *Clarias mossambicus*; seen by transmitted light. Magnification *c.* × 20

ditions the stream overflows its banks, inundating the low-lying *Echinochloa* zone, which becomes a temporary and shallow swamp. Attention was drawn to the presence of adult *C. mossambicus* (normally absent from this stream) by the large number of African fishermen seen spearing these fish. A small sample of speared fish examined showed that females had either ovulated or were likely to ovulate within a short period. All male fish caught were apparently ripe.

Evidence indicating when sexually active fish first ascended the stream is both scanty and equivocal. African fishermen claimed that fish first appeared on April 11; on the other hand, subsequent collections of larvæ demonstrated the presence of young fish at least three weeks older than those known to have been spawned on April 12. More positive evidence is available regarding the time by which adults had returned to the lake. From both fishing activity and personal observation, it seems that few adults remained in the stream four days after fertilized eggs were first found. At this time the extent of the stream and swamp was greatly reduced.

Fertilized eggs were found among the accumulated plant debris lying in pools and side runnels of the main stream. Despite intensive search, very few eggs were found in the main stream or in sites from which the debris had been scoured by the flood. A surprising feature in the spatial distribution of eggs and early larvæ was their dispersion, in small groups of from five to ten individuals, over a considerable area.

The fertilized ovum is small and sub-elliptical in cross-section, having mean greatest and least diameters of 2·0 mm. and 1·5 mm. respectively. The translucent straw-yellow yolk almost fills the vitelline space. A characteristic feature is the large adhesive disk, about 0·5 mm. deep, which entirely surrounds one pole. The outer surface of this disk follows the general contour of the underlying chorion; at its centre there is a well-marked pit-like depression (Fig. 1). Sheets of a glutinous and elastic substance which are extruded from the disk firmly anchor the egg to the substrate.

Since an accurate temporal base-line is known only for laboratory-raised embryos obtained in the first instance by artificial fertilization, the developmental times given below refer to these individuals.

Within an hour of fertilization the fourth blastodermal cleavage has taken place, the blastodermal disk occupying the pole opposite the adhesive disk. After nine hours there is a well-defined embryonic shield lying equatorially. Hatching takes place between twenty-three and twenty-five hours after fertilization. For comparison, it may be noted that *Tilapia esculenta* and *T. leucosticta* raised under similar conditions hatch between five and six days after fertilization. Newly hatched *C. mossambicus* larvæ are 3·5–4·0 mm. long; the first two gill slits are open, and there is a clearly defined opercular fold. The larvæ swim actively, and are not confined to the substrate. A small, but distinct, ventral sucker is developed on the vitelline membrane. The adhesive properties of this sucker are considerably less than those of the chorionic adhesive disk.

Development after hatching is also rapid, especially during the first fifty hours. Perhaps the most outstanding morphological features of this period are the large olfactory sacs, which dominate the anterior cephalic region, and the precociously developed circum-oral barbels.

Between thirty-seven and thirty-nine hours after hatching, an extensive and well-developed vascular network is visible on the expansive branchiostegal membrane. At this stage the operculum is clearly defined, and two cartilaginous branchiostegal rays are present. Preliminary investigation leads me to interpret the branchiostegal vascular net as an extension of the hyoidean vascular arch, without its subdivision into afferent and efferent vessels. Blood flows into this network from the ventral aorta, and after circulating through the net is collected into a single vessel which joins the paired dorsal aortæ behind the eye. It is suggested that the hyoidean vascular net functions as an accessory gill. In larvæ one week old these vessels may still be traced, but thereafter increased pigmentation precludes further direct observations on living material.

The yolk sac is completely resorbed four days after hatching, at which time the larvæ have attained a length of 7–8 mm. and are clearly recognizable as young *Clarias*. The vitelline sucker ceases to be functional at about this period, and is soon lost.

Embryos raised *in vitro* were kept within the temperature-range of 23·0–24·5° C., whereas under natural conditions embryos were subject to a diurnal temperature variation as great as 6 deg. C. (22°–28°). So far as could be determined, development *in vivo* was slower than in the laboratory, there being a time lag of nearly 100 per cent during pre-hatching development, later reduced to 25 per cent by the time that the yolk had been resorbed. Oxygen tension, probably associated with the intensity and turbulence of water flow, is doubtless an important feature in controlling developmental rates. It was noticed, for example, that early development was faster in embryos raised in dishes with a strong current agitating the water than in those supplied with only a slight water flow. Larvæ resulting from artificial fertilization did not survive beyond five days after hatching.

The temporary nature of the spawning area is emphasized by the fact that six days after the discovery of early embryos, the principal spawning site was completely isolated from the main stream. Also at this time, larvæ were first found in the stream; these were at a developmental stage comparable with those still remaining in isolated areas of the swamp. A rapid fall in water-level now occurred, which resulted in many larvæ being concentrated in small isolated pools approximately a foot in diameter and six inches deep. In one such pool the midday surface temperature was 34° C., while six inches below, the temperature of the mud was 25° C. Larval fishes continued to live under these conditions for three days without any marked diminution in their numbers. Finally, on the fourth day the pools dried out completely.

Collections made in the main stream indicated a fairly constant and dense population of young fish over a period of eight days after the first appearance of larvæ in this habitat; however, with the gradual break-up of the stream into disconnected pools, the number of larvæ decreased suddenly and has remained at a low level for some weeks. If these environmental conditions are typical for this period of the 'long' rains, then it would seem probable that larval *C. mossambicus* suffer severe mortality before reaching the lake. On the other hand, rainfall in this area during March and April had been unusually light and irregular.

It has not yet been determined at what stage in the life-history young fishes find their way into the lake.

A full description of embryonic and larval development in *C. mossambicus* will be published elsewhere.

P. H. Greenwood

East African Fisheries Research Organization,
Jinja, Uganda.
May 23.

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Elementary Bodies in Bovine Malignant Catarrh

Malignant catarrh in cattle is widespread, occurring in Africa, America and Europe. Henning[1] has described the clinical syndrome which invariably terminates in death. The etiological agent, although believed to be a virus, has never been described. The disease can be transmitted to cattle by needle passage of spleen/gland emulsions[2]. It has also been adapted to rabbits[3].

The rabbit-adapted strain affords an easier and more economical means of investigation, and, in view of Mettam's[4] remarks that "The virus must be fairly large and only invisible because of some natural peculiarity . . .", it was decided to make a minute examination of smears and sections obtained from various infected rabbit tissues. Using Castaneda, Macchiavello and Giemsa staining, it was observed that elementary and initial type bodies were present in most tissues, but especially spleen, gland, lung and appendix, which resemble those of the psittacosis group of viruses (Fig. 1). These bodies showed the pleomorphism, colour variation and location as described by Bedson and Bland[5].

A check was then made on smears and sections of bovine tissues already prepared, and although the virus is present it is much less numerous and more likely to be confused with cellular debris.

An attempt was also made to establish the disease in fertile hens' eggs using 0·2 c.c. of a 10 per cent spleen emulsion from an infected rabbit, but after only two passages in the yolk sac of eight-day old embryos it was unavoidably necessary to discontinue this work for some months. Smears from yolk sac and chorio-allantoic membrane revealed various forms of the virus, but elementary bodies were undetectable.

In view of the fact that psittacosis virus can be stored for some months by placing infected yolk sacs in deep freeze, and despite the fact that the virus of malignant catarrh will only remain viable for one to two weeks according to all previous investigators, it was decided to place one yolk sac in a sterile container in the deep freeze at − 10° C. At the same time the bovine needle passages were also discontinued, but passages in rabbits were maintained. However, after four months from this time (fifty-seventh passage), the rabbits failed to react.

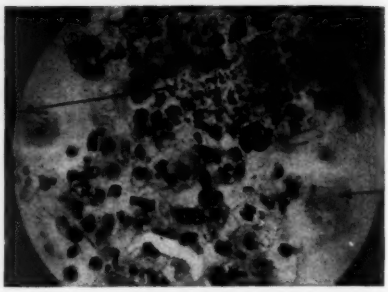

Fig. 1. Rabbit lung stained with Giemsa. Initial bodies, mainly intracellular, are marked by arrows. × 660

After eight months, when it was possible to resume the work, the frozen yolk sac was emulsified in nutrient broth to make a 10 per cent yolk sac emulsion, and 0·2 c.c. was inoculated into the yolk sac of eight-day old fertile hens' eggs. After a further two passages, 10 c.c. of a 10 per cent whole egg emulsion was inoculated into the prescapular glands of two cattle.

Four weeks later one animal reacted with symptoms associated with malignant catarrh, and this was confirmed by post-mortem findings. A 10 per cent spleen/gland emulsion from this animal was sub-inoculated into a further two animals by the prescapular gland route, and after three weeks one of the animals reacted, again with typical clinical and post-mortem findings associated with malignant catarrh. Using whole egg emulsion from the fourth egg-passage after storage, a further four cattle were inoculated intratracheally. Three reacted in three to four weeks, again with typical symptoms; but one of these, a young native bull, survived. Thus, a complete cycle, bovine—rabbit—fertile hens' eggs—bovine, has been completed.

Natural infections of malignant catarrh have not been recorded at Kabete.

Papers embodying the results of these studies are being prepared and will be published elsewhere.

D. Danskin

Veterinary Research Laboratory,
P.O. Kabete, Kenya.
April 15.

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New Free Amino-Acids in Plant Materials

Recent research[1] indicates the presence of 5-hydroxypipecolinic acid as well as possibly hydroxylysine, besides pipecolinic acid and baikiain in the non-protein nitrogenous fraction of plant materials.

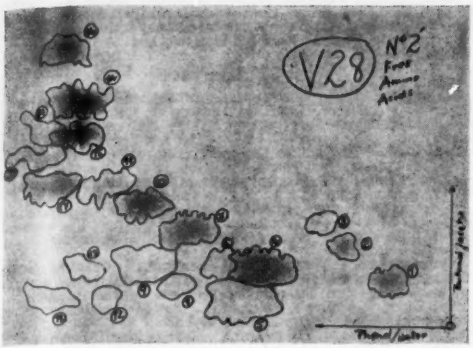

Fig. 1. Ethanolic extract of lucerne hay cut at 14 cm. First phase: phenol–water (4 : 1)/ammonia atmosphere. Second phase: *n*-Butanol/acetic acid/water (4 : 1 : 5, upper layer). Ninhydrin development: 1, Aspartic acid; 2, glutamic acid; 3, 3 : 4 - dihydroxyphenylalanine; 4, serine; 5, asparagine; 6, glycine; 7, threonine; 8, citrulline; 9, glutamine; 10, alanine; 11, *β*- alanine; 12, histidine; 13, unknown (? ε-aminohydroxycaproic acid or methionine sulphone); 14, valine + methionine; 15, γ-aminobutyric acid; 16, leucines; 17, proline; 18, arginine + lysine; 19, pipecolinic acid; 20, baikiain

Previously unidentified ninhydrin-reactive substances have been found to occur in the hydrolysed[2a] and unhydrolysed[2b] ethanolic extracts of lucerne hay cut in different stages of growth and in certain marine algae[3], as well as the extract of fenugreek seeds[2a].

Fig. 1 shows a two-dimensional paper chromatogram of the ethanolic extract of lucerne hay cut at 14 cm. in height (Libčchov). Among the ninhydrin-reactive spots occurring on the chromatogram are those corresponding to pipecolinic acid (spot 19), baikiain (spot 20) as well as citrulline (spot 8) and possibly ε-aminohydroxycaproic acid or methionine sulphone (spot 13). The work of Kolouŝek indicates that pipecolinic acid is present in mature lucerne hay (Tábor) as well as citrulline[4].

An identical picture is given by the ethanolic extract of lucerne hay cut at 12 cm. in height.

A further unknown ninhydrin-reactive substance occurs sometimes near asparagine (with the same R_P in phenol–water/ammonia as glycine but just below asparagine). This may be ethanolamine phosphate or α-ε-diaminopimelic acid (Work, E., personal communication).

5-Hydroxypiperidine-2-carboxylic acid does not seem to occur in these hays, but an unknown ninhydrin-reactive substance is found in certain marine algae[3] in the position of this amino-acid on two-dimensional paper chromatograms (it only gives a weak reaction with alloxan and isatin)[2b,c].

A brown ninhydrin colour is given by another unknown substance occurring in the hydrolysates of ethanolic extracts of lucerne hay[2a].

Spot 3 is thought to be 3 : 4-dihydroxyphenylalanine[2b].

C. B. Coulson

"Inglehurst",
6 Drury Road,
Colchester.
May 24.

[1] Grobbelaar, N., Pollard, J. K., and Steward, F. C., *Nature*, **175**, 703 (1955).

[2] (*a*) Kolouŝek, J., and Coulson, C. B., *J. Sci. Food and Agric.* (Pt. IV) (in the press). (*b*) *Chem. Listy*, **46**, 186 (1952).

[3] (*a*) Coulson, C. B., *Chem. and Indust.*, 971 (1953); (*b*) Institute of Seaweed Research, Report No. 171 (December 1953). (*c*) *J. Sci. Food and Agric.* (Pt. V) (in the press).

[4] Kolouŝek, J., *Chem. Listy*, **47**, 473 (1953); *J. Sci. Food and Agric.*, **6**, 380 (1955).

Isolation of Ectotrophic Mycorrhizal Mycelia from Rhizomorphs present in Soil

In a recent communication in *Nature*, Warcup[1] described a technique devised for the isolation of fungi directly from hyphæ distributed in soil. By this method he succeeded in isolating a number of fungal species including basidiomycetes generally absent from dilution plates.

During researches on soil fungi carried out at Bedford College, mycelia known to form ectotrophic mycorrhizal associations have been isolated from soil rhizomorphs using the following method: fresh rhizomorphs picked out of the soil were washed for approximately 10 sec. in 0·1 per cent hydrochloric acid, then rinsed in sterilized water and plated on nutrient media commonly used for culturing mycorrhizal fungi. In this way *Boletus bovinus*, *B. scaber* and *Mycelium radicis nigrostrigosum* were isolated from soil brought in from the field and from experimental soil cultures grown in the laboratory.

The accompanying photograph shows a sample of rhizomorphs of *B. bovinus* used for isolation purposes. These hyphal strands, present in a certain heathland soil under investigation, exhibit a pinkish-brown colour. Their average diameter is 60–70μ. Each rhizomorph consists of a central cylinder formed by 1–3 hyphæ 4–5μ wide, enclosed within a sheath of more slender hyphæ each 2–3μ in diameter. Clamp connexions have not been observed in the hyphal filaments forming these rhizomorphs. In the particular soil mentioned above, *B. scaber* and *M. r. nigrostrigosum* were observed to develop hyphal strands structurally not dissimilar from those described for *B. bovinus*.

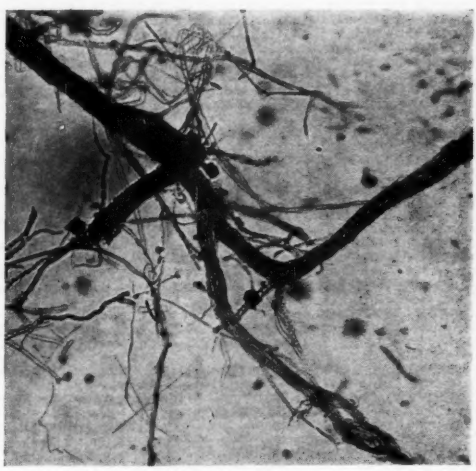

Fig. 1. Soil rhizomorphs of *Boletus bovinus* as used for the purpose of isolation. × 140

The isolation of ectotrophic mycorrhizal mycelia from soil rhizomorphs by means of surface sterilization has proved a convenient method of obtaining pure cultures of these fungi which, so far, have resisted isolation from individual hyphæ.

Ida Levisohn

Bedford College
(University of London),
Regent's Park, London, N.W.1.
June 3.

[1] Warcup, J. H., *Nature*, **175**, 953 (1955).

FORTHCOMING EVENTS

Monday, September 12

INSTITUTE OF METAL FINISHING (at the Northampton Polytechnic, St. John Street, London, E.C.1), at 6.15 p.m.—Mr. F. Wild: "Fluoborates in Plating".

Monday, September 12—Friday, September 16

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY (at the Royal Institution, Albemarle Street, London, W.1)—Third London Symposium on "Information Theory".

Tuesday, September 13—Saturday, September 17

SOCIETY OF DYERS AND COLOURISTS (at the Northern Counties Hotel, Portrush, Co. Antrim, N. Ireland)—Symposium on "Bleaching, Dyeing and Finishing To-day".

Wednesday, September 14—Saturday, September 17

NATIONAL PHYSICAL LABORATORY (at Teddington)—Symposium on "Cavitation in Hydrodynamics".

Friday, September 16

BIOCHEMICAL SOCIETY (in the Department of Biological Chemistry Marischal College, Aberdeen), at 2.15 p.m.—Scientific Papers.

Saturday, September 17

NUTRITION SOCIETY, SCOTTISH GROUP (in the Physiology Lecture Theatre, Marischal College, Aberdeen), at 1.40 p.m.—Symposium on "Cholesterol and Fat Metabolism in Relation to Diet and Disease".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN APPLIED MATHEMATICS—The Registrar, The University, Nottingham (September 19).

READER IN APPLIED MATHEMATICS at the Imperial College of Science and Technology, London, S.W.7—The Academic Registrar, University of London, Senate House, London, W.C.1 (September 21).

RESEARCH ASSISTANTS (2) (with a good honours degree in physics or physical chemistry) IN THE DEPARTMENT OF MINING—The Registrar, The University, Leeds 2 (September 23).

ASSISTANT PHYSICIST (with a good honours degree in physics and preferably with experience in electronics and nuclear physics techniques) IN THE PHYSICS DEPARTMENT of the Sheffield National Centre for Radiotherapy—The Secretary, Sheffield Regional Hospital Board, "Broom Cross", Tree Root Walk, Sheffield 10 (September 24).

PHYSICIST (with a first- or second-class honours degree or equivalent, and preferably with some experience of optics, heat transfer, or radiation problems) at a Ministry of Supply Research Station near Salisbury, Wilts—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.312/5A (September 24).

LECTURER IN CIVIL ENGINEERING—The Registrar, The University, Leeds (September 26).

ASSISTANT LECTURER IN PHYSICS—The Registrar, University College of North Staffordshire, Keele, Staffs (September 30).

LECTURER IN ORGANIC CHEMISTRY—The Secretary, Queen's University, Belfast (September 30).

LECTURER IN THE DEPARTMENT OF BIOCHEMISTRY—The Secretary of University Court, The University, Glasgow (September 30).

LIBRARIAN (with recognized qualifications in librarianship and experience in a special library, and preferably with a knowledge of botany and major foreign languages) OF THE ROYAL BOTANIC GARDEN, Edinburgh—Chief Librarian, Ministry of Works, Lambeth Bridge House, London, S.E.1 (September 30).

SENIOR LECTURER IN ANTHROPOLOGY at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 30).

LECTURER IN FARM MANAGEMENT—The Secretary and Registrar, University College of North Wales, Bangor (October 1).

LECTURER or ASSISTANT LECTURER IN BIOCHEMISTRY—The Registrar, The University, Sheffield (October 1).

SENIOR LECTURER, LECTURER or ASSISTANT LECTURER IN INORGANIC CHEMISTRY at the University College of Khartoum, Sudan—The Secretary, Inter-University Council, 1 Gordon Square, London, W.C.1 (October 1).

CHIEF ASSISTANT CHEMIST AND BACTERIOLOGIST (Associate or Fellow of the Royal Institute of Chemistry, and preferably with experience of water analysis and treatment)—The Engineer and General Manager, Sunderland and South Shields Water Company, 29 John Street, Sunderland, quoting "Chemist and Bacteriologist" (October 15).

LECTURER IN PHILOSOPHY at Auckland University College (University of New Zealand)—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, October 15).

LECTURER (proficient in anatomy and cytology and preferably with a good knowledge of cytogenetics) IN THE UNIVERSITY DEPARTMENT OF BOTANY, University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Johannesburg, October 15).

SENIOR LECTURER (with teaching experience at university level and an honours degree and a research degree in zoology) IN ZOOLOGY at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, October 31).

AGRICULTURAL OFFICERS (with a university degree in agriculture or natural science) in the Gold Coast Local Civil Service, to advise the Director of Agriculture on current district agricultural problems, to manage District Agricultural Stations, and to implement agricultural policy in their respective districts—The Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting BCD.63/13/04.

ELECTRONIC PHYSICISTS and ENGINEERS, Scientific Officer or Experimental Officer class, at Ministry of Supply Experimental Establishments near Farnborough, Hants; Malvern, Worcs; Sevenoaks, Kent; Aberporth, S. Wales; and London H.Q., for research and development on guided weapons; radio, radar and communications; and electronic devices—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.302/5A.

HOSPITAL PHYSICIST (with an honours degree in physics, and preferably with experience in hospital physics) IN THE RADIOTHERAPY DEPARTMENT—The Secretary, Romford Group Hospital Management Committee, Romford.

MECHANICAL and AERONAUTICAL ENGINEERS, AERODYNAMICISTS, APPLIED MATHEMATICIANS, PHYSICISTS and PHYSICAL CHEMISTS (with a first- or second-class honours degree or equivalent qualification) at the Ministry of Supply National Gas Turbine Establishment, near Farnborough, Hants—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting C.661/5A.

RESEARCH ASSISTANT (with an honours degree or equivalent qualification in electronics) IN THE DEPARTMENT OF PHYSIOLOGY for work on auditory physiology—The Secretary, Charing Cross Hospital Medical School, 62 Chandos Place, London, W.C.2.

SCIENTIFIC OFFICER (with a first- or second-class honours degree or equivalent in physics, mechanical or chemical engineering) at the Ministry of Supply Research and Development Establishment, Waltham Abbey, Essex, to assist in research on heat transfer phenomena at high temperatures—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.329/5A.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Department of Scientific and Industrial Research. Report of the Fuel Research Board with the Report of the Director of Fuel Research for the year 1954. Pp. vi+70+2 plates. (London: H.M. Stationery Office, 1955.) 3*s*. net. [17

The Suppressed Frame System of Telerecording. (B.B.C. Engineering Monograph—No. 1.) Pp. 15. (London: British Broadcasting Corporation, 1955.) 5*s*. (Annual subscription covering about six issues: 20*s*.) [17

British Empire Cancer Campaign. Thirty-second Annual Report covering the year 1954. Pp. xxx+531. (London: British Empire Cancer Campaign, 1955.) [17

Ministry of Fuel and Power. Reports of H.M. Inspectors of Mines under the Coal Mines Act, 1911, for the year 1954. South Western Division. By T. A. Jones. Pp. ii+24+3 plates. (London: H.M. Stationery Office, 1955.) 1*s*. 6*d*. net. [17

Rothamsted Experimental Station. (Lawes Agricultural Trust.) Report for 1954. Pp. 242. (Harpenden: Rothamsted Experimental Station, 1955.) 7*s*. 6*d*. [47

Universities Council for Adult Education. Report on the year 1953–1954. Pp. 28. (Bristol: W. E. Salt, The University (Hon. Secretary and Treasurer).) 1955. [47

Other Countries

Veröffentlichungen des Fraunhofer Instituts Freiburg I.B. Sonnen-Zirkular für die Monate Januar, Februar, März, 1955. Pp. 38. (Freiburg im Breisgau: Fraunhofer Institut, 1955.) [17

Tobacco Research Board of Rhodesia and Nyasaland. Bulletin 4 (June 1955): Frog Eye and Barn Spot. By R. C. Stephen. Pp. 36. (Salisbury: Tobacco Research Board of Rhodesia and Nyasaland, 1955.) [47

Metropolitan Life Insurance Company. Statistical Bulletin, Vol. 36, No. 5: Hospitalization of Men at Ages 60 and Over. Pp. 12. (New York: Metropolitan Life Insurance Company, 1955.) [47

Annuario Sismologico de Portugal. No. 5—1951. Pp. 7. (Lisboa: Servico Meteorologico Nacional, 1955.) [47

United States Naval Observatory. Circular No. 58: Positions, Areas, and Counts of Sunspots, January–February–March, 1955. Pp. 7. (Washington, D.C.: United States Naval Observatory, 1955.) [47

Annual Epidemiological and Vital Statistics, 1952. Part 1: Vital Statistics and Causes of Death. Part 2: Cases of and Deaths from Notifiable Diseases. Pp. 544. (Geneva: World Health Organization; London: H.M. Stationery Office, 1955.) 30 Swiss francs; 50*s*.; 7.50 dollars. [47

Proceedings of the Ninth Meeting of the Animal Husbandry Wing of the Board of Agriculture and Animal Husbandry in India. (Convened by the Indian Council of Agricultural Research, Izatnagar, 11th to 17th March, 1951.) Pp. x+166. (Delhi: Manager of Publications, 1954.) Rs. 10/10/–; 17*s*. [67

United States. Commission on Organization of the Executive Branch of the Government. Subcommittee Report on Research Activities in the Department of Defense and Defense Related Agencies. Pp. x+91. (Washington, D.C.: Government Printing Office, 1955.) 30 cents. [67

Gold Coast. Annual Report of the Forestry Department for the year ended 1953–54. Pp. iii+46+1 map. (Accra: Government Printer, 1955.) 2*s*. 6*d*. [67

Ontario Research Foundation. Annual Report, 1954. Pp. 30 (4 plates). (Toronto: Ontario Research Foundation, 1955.) [67